Wed Sept 10th 2014.

CIVL 498C Life Cycle Assessment

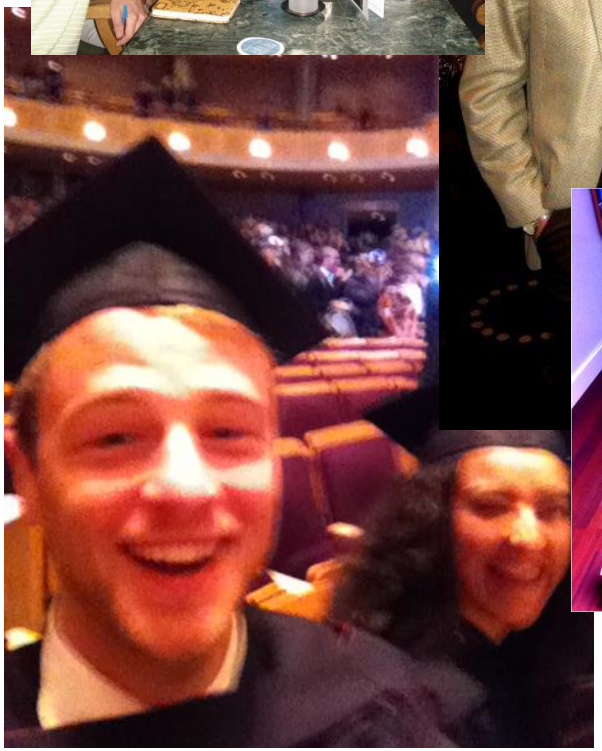
Week 2: LCA Basics and Development

Presentation Outline

1. **About me**
2. History
3. LCA method
4. Sustainability Framework

Mark Goedkoop

Wayne Trusty



Coldstream Consulting

Life Cycle Assessment Alliance

UBC

Athena Sustainable Materials Institute

2006 2007 2008 2009 2010 2011 2012 2013

CIVL 498C
Life Cycle Assessment

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Affiliations:

Adjunct Professor, UBC Dept. Civil Eng.
Research Associate, Athena Institute
Founding Member, LCA Alliance

CIVL 498C - Life Cycle Assessment

2011/2012

2010/2011

2009/2010

2008/2009

- 4th year Civil Eng technical elective
- Established in January 2009*
- Attended by undergraduate and graduate architecture and engineering students from civil, mechanical, materials, environmental, chemical and mining specializations

2012/2013

2013/2014

*http://sustain.ubc.ca/sites/sustain.ubc.ca/files/seedslibrary/CIVLArticle_draft1_2_0.pdf

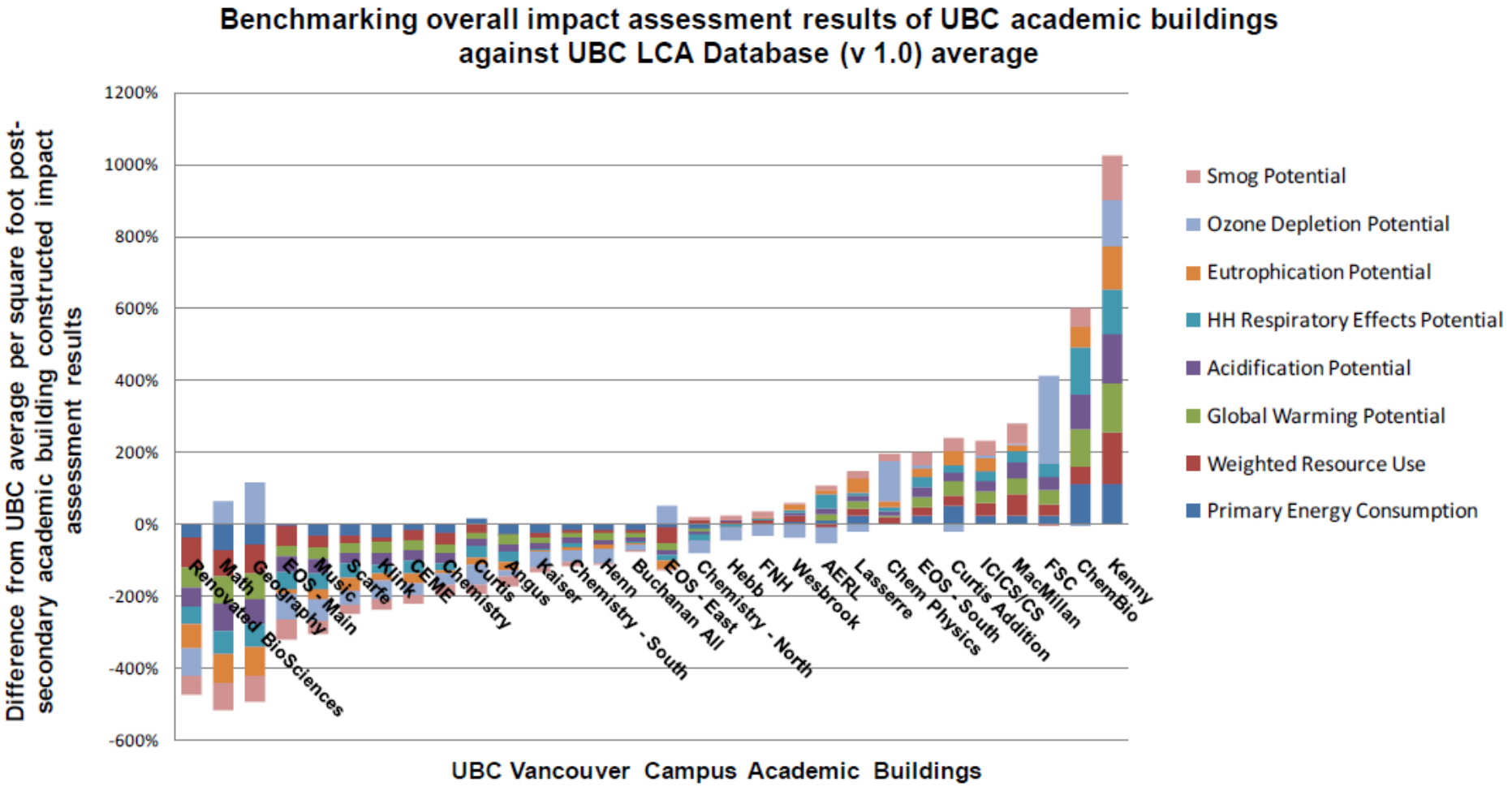


Figure 9 Renovating scenario benchmarked alongside UBC academic buildings against the UBC average per square foot post-secondary academic building constructed impact assessment result.

Life
Cycle
Assessment
Alliance

LCA group of students and young professionals at UBC.

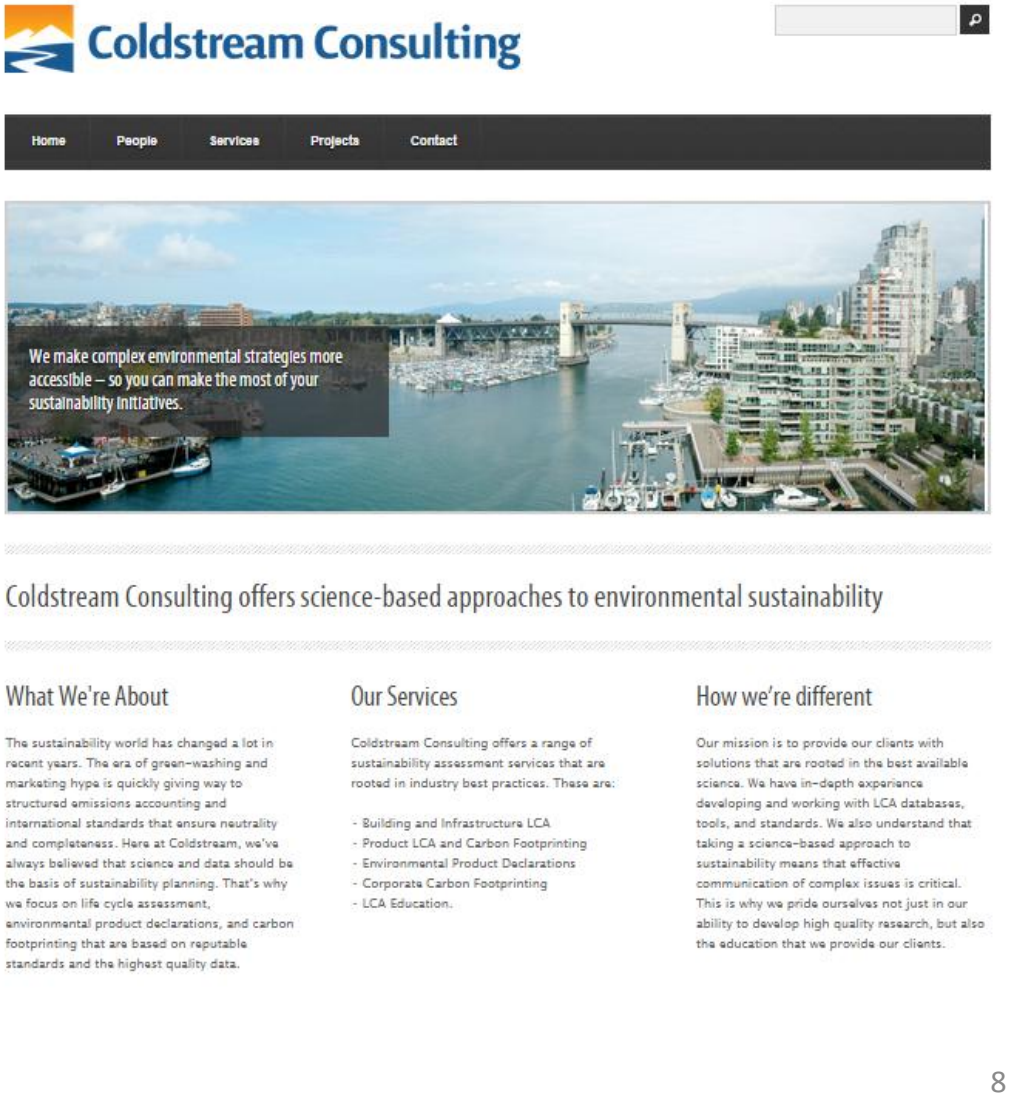
www.lcaalliance.com

Join the mailing list to keep in touch about meetings, events and other discussions.

Matt Bowick

Rob Sianchuk

James Salazar



Coldstream Consulting

CONSUMER AND CONSTRUCTION PRODUCTS

- Structural Wood Product Environmental Product Declarations for the American Wood Council
- Garment and Paper LCA for Offsetters Clean Technology

ENERGY AND MAJOR INFRASTRUCTURE

- District Energy Center LCA for UBC Project Services
- Keeyask Generation Station LCA review for Manitoba Wildlands

WHOLE BUILDINGS AND ASSEMBLIES

- Roof Envelope LCA for RJC Consulting Engineers
- Wesbrook Community Center LCA for UBC Properties Trust

ORGANIZATION

- Carbon footprinting and LCA research for Vancity Credit Union

LCA DATABASES

- Athena LCI Database
- US LCI Database
- UBC LCA Database

LCA CALCULATION TOOLS

- Athena EcoCalculator, Impact Estimator for Buildings and Impact Estimator for Highways
- Carbon Sequestration Calculator for EPDs of North American Wood Products
- Residential Batch Environmental Assessment Tool

LCA GUIDANCE DOCUMENTS

- LCA Protocol for Hydroelectric Generation Station Projects in Manitoba
- Athena Guide to Whole-Building LCA in Green Building Programs
- LCA in the Canadian Boreal Forest Agreement: Methodology, Case Studies, and Guidance

Presentation Outline

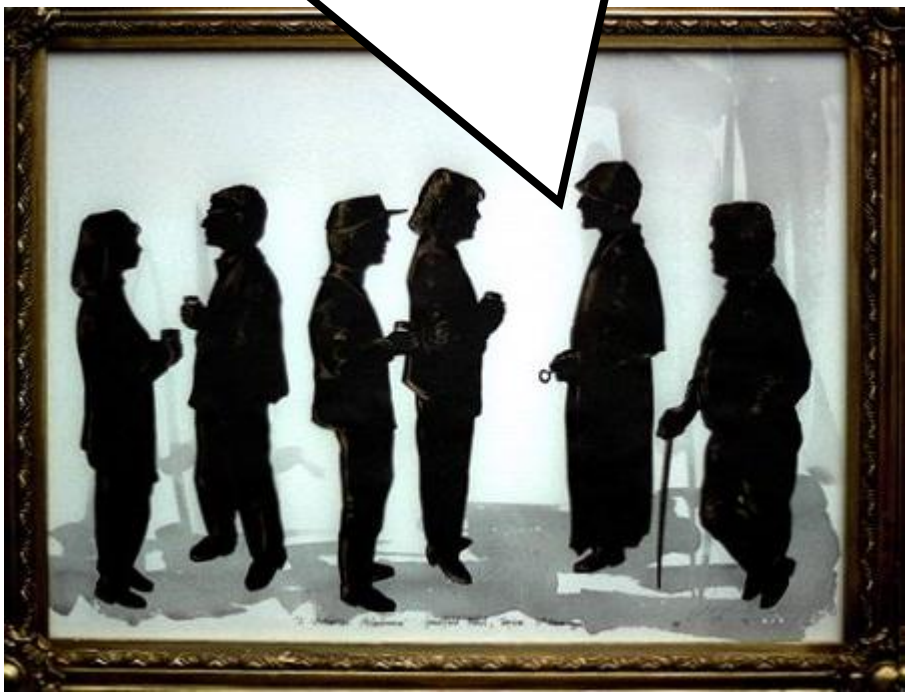
1. About me
2. **History**
3. LCA method
4. Sustainability Framework

What is life cycle assessment?

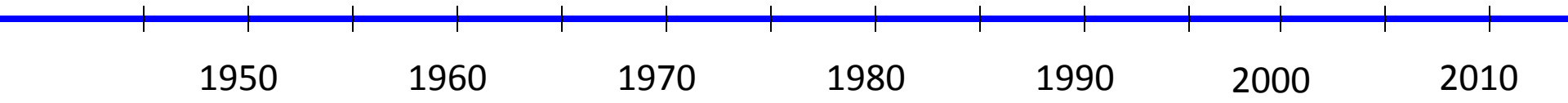
"It's a scientific method used to quantify the impacts created by products over their life cycle."

Usually environmental

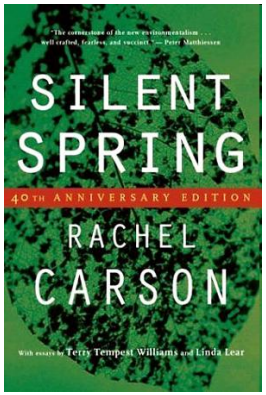
ie. goods and services.



LCA Building Blocks

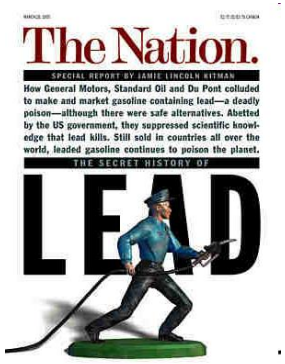


Public | Community | Data | Methodology | Tools | Education

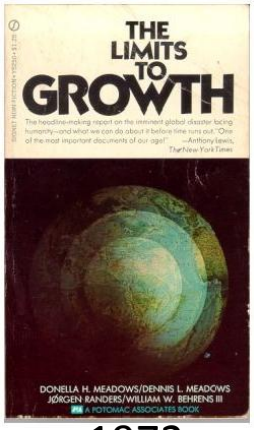


1962

Leaded Gas



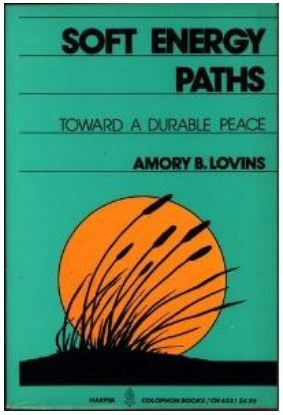
1965



1972

Oil Embargo

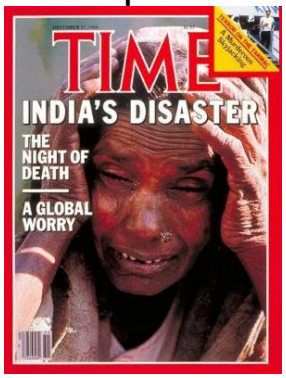
1973



1976

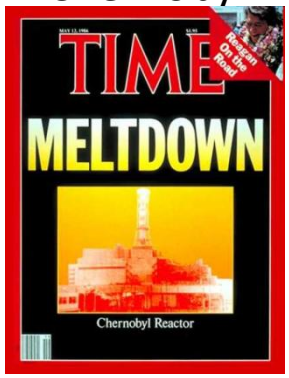
Sevesco

Bophal



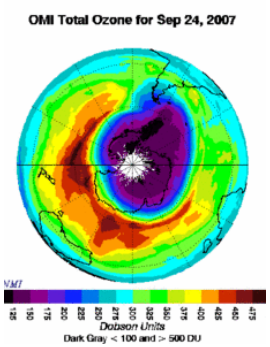
1984

Chernobyl



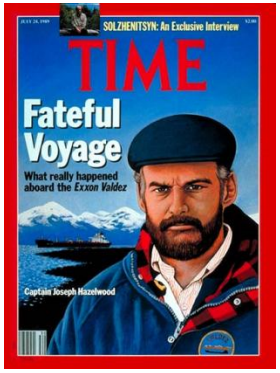
1986

Ozone Hole



1987

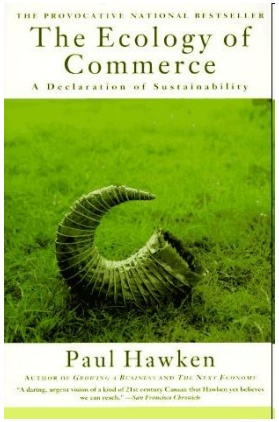
Valdez



1989

Global Warming

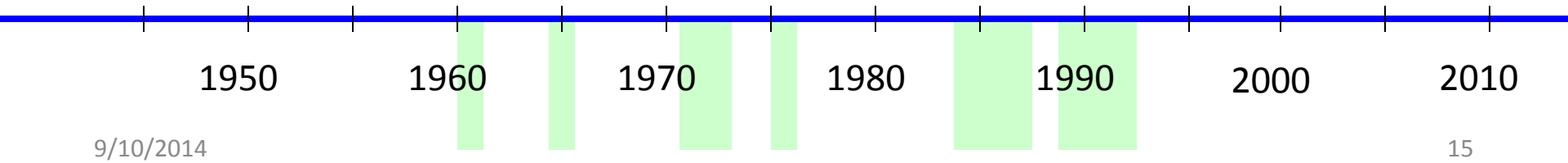
1992



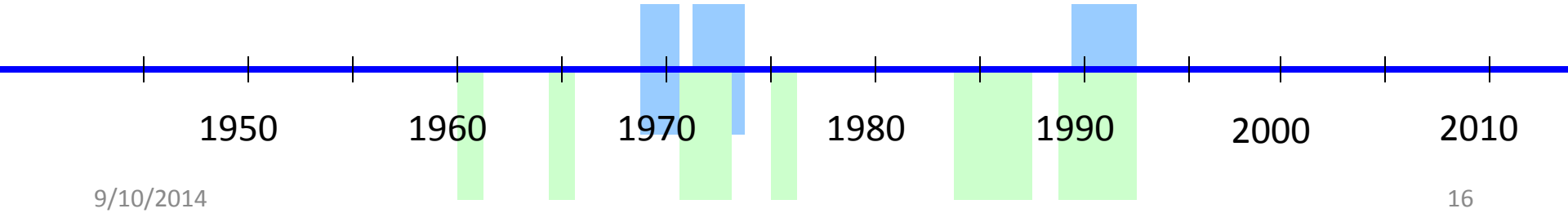
1993

1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010

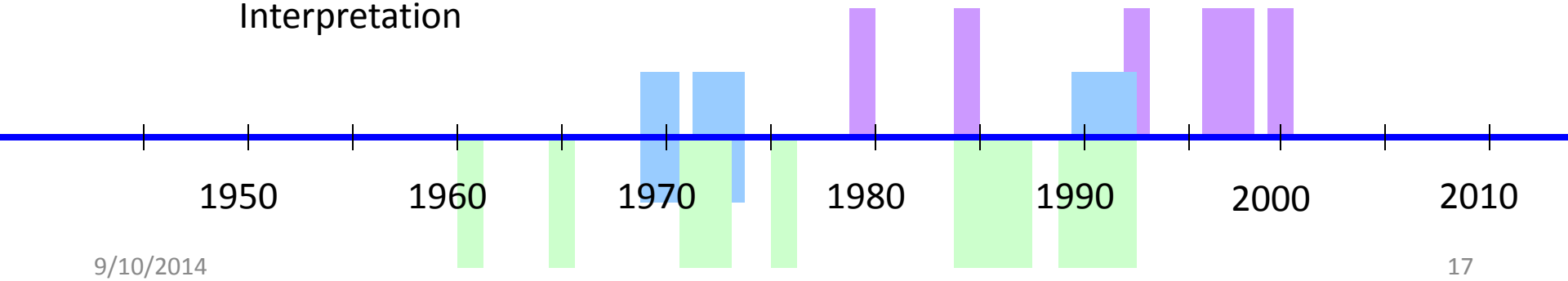
What motivated you to become concerned the impacts caused by human activity?



	Service Demanders	Service Suppliers	
1969	Coca-Cola	Midwest Research Institute	(beverage containers)
1970		Bruce Hannon	(beverage containers)
1972	Federal Ministry of Education and Research	Battelle-Institute	(packaging waste)
1973	Tetra Pak	Gustav Sundström	(beverage packaging)
1990		Society of Environmental Toxicology and Chemistry (SETAC)	
1991		International Chamber of Commerce Federation of Swedish Industries	
1992		Society for the Promotion of Life Cycle Development (SPOLD)	



	Contribution	Produced By
1979	Handbook on Energy Analysis	Boustead and Hancock
1984	concept of Impact Assessment	BUS
1993	Code of Practice	SETAC
1997	ISO 14040 – Principles and Framework	International Organization for Standardization (ISO)
1998	ISO 14041 – Goal & Scope Definition and Inventory Analysis	ISO
2000	ISO 14042 – Life Cycle Impact Assessment	ISO
	ISO 14043 – Life cycle Interpretation	



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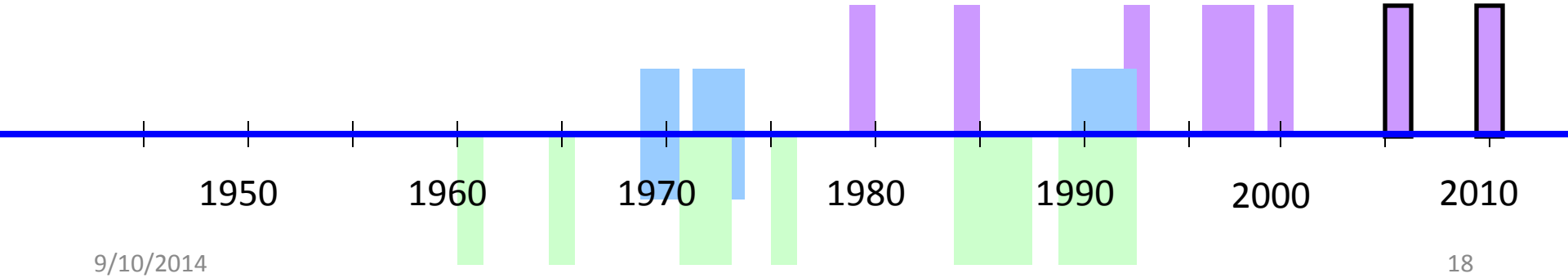
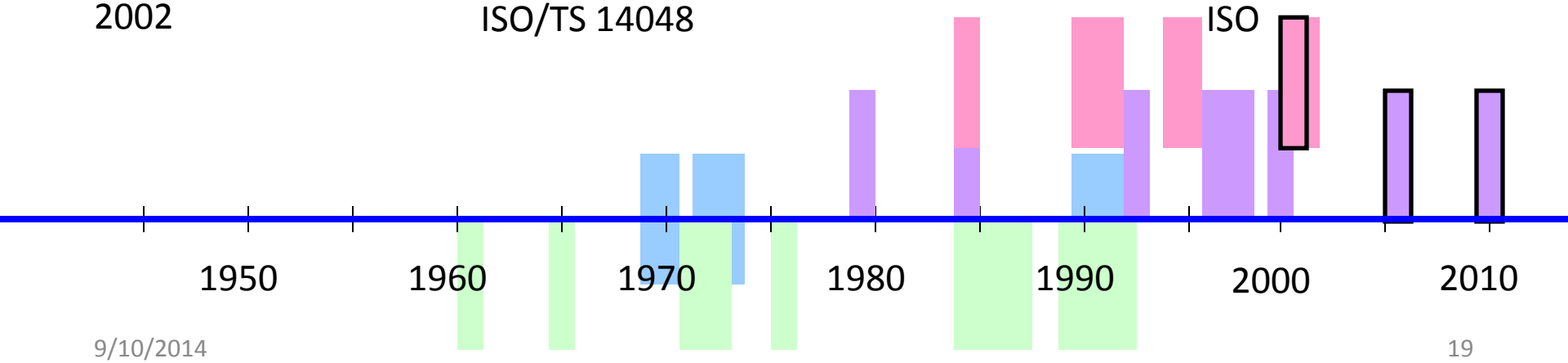
1993	Code of Practice	SETAC
1997	ISO 14040 – Principles and Framework	International Organization for Standardization (ISO)
2006	ISO 14044 – Requirements and Guidelines	ISO
	ISO 14040 – Principles and Framework	
2010	ISO 21931-1 – Sustainability in Building Construction	ISO



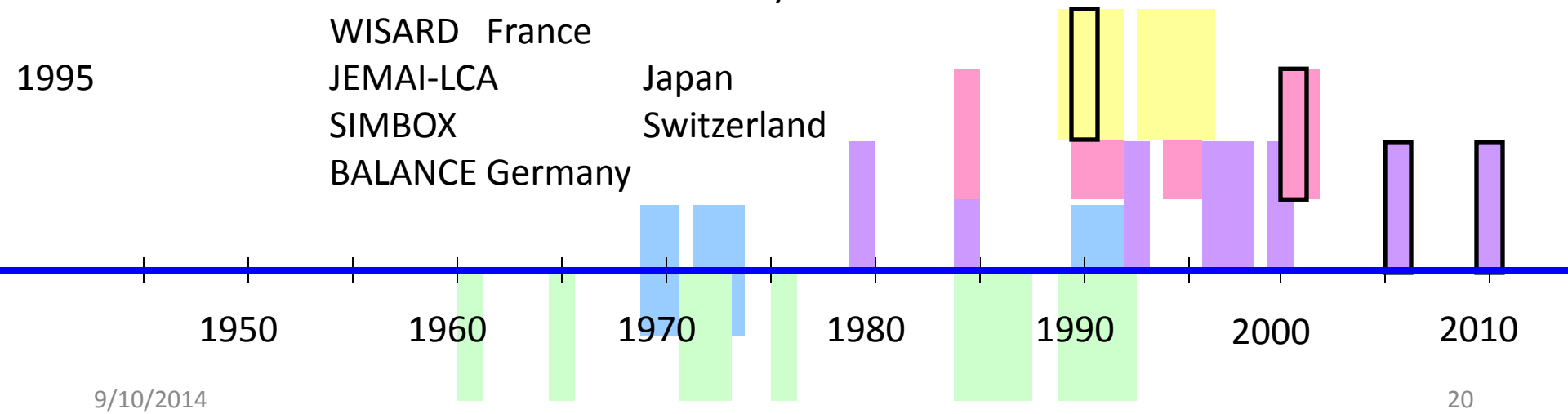
	Database Name	Content	Country
1984	BUS	Packaging	Switzerland
1990	BUWAL	Packaging	Switzerland
		Packaging	Denmark
1991		Packaging	Sweden
2001	US LCI	Various	US & Canada

	Data Format	Country
1994	SPINE	Sweden
1995	SPOLD	Belgium
2002	ISO/TS 14048	ISO



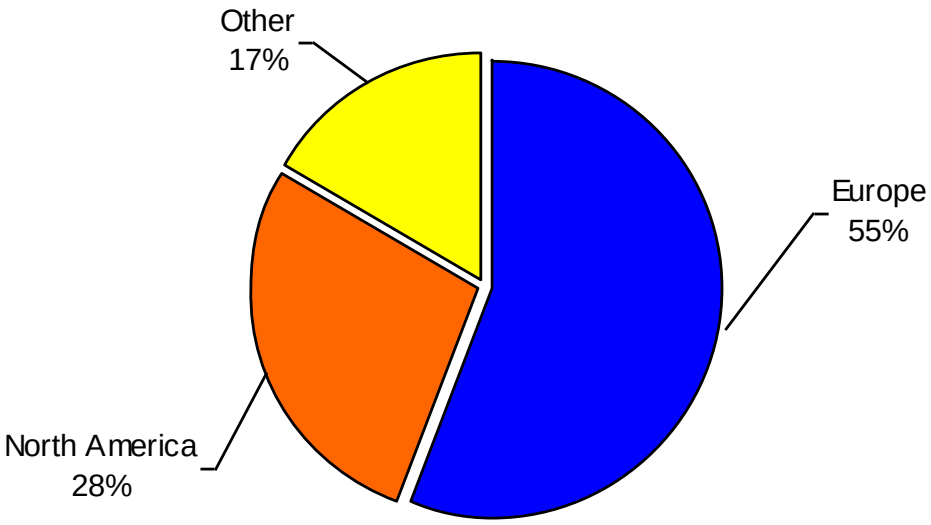
Public | Community | Methodology | Data | Tools | Education

	Tool Name	Country
1989	GEMIS	Germany
1990	Boustead Model	UK
	PEMS	UK
	SimaPro	Netherlands
1991	LCAiT	Sweden
1993	GaBi	Germany
	KCL Eco	Finland
	REGIS	Switzerland
	EcoScan	Netherlands
1994	TEAM	France
	Umberto	Germany
	WISARD France	
1995	JEMAI-LCA	Japan
	SIMBOX	Switzerland
	BALANCE Germany	



~1995 First courses taught in universities

2009 Started CIVL 498C –
Whole Building Life Cycle Assessment



Of 17 respondents to a informal 2009 survey of LCA courses offered

[Check out Hitchiker's Guide to LCA. Is an excellent LCA 101 type read.](http://www.amazon.com/Hitch-Hikers-Guide-LCA/dp/9144023642)
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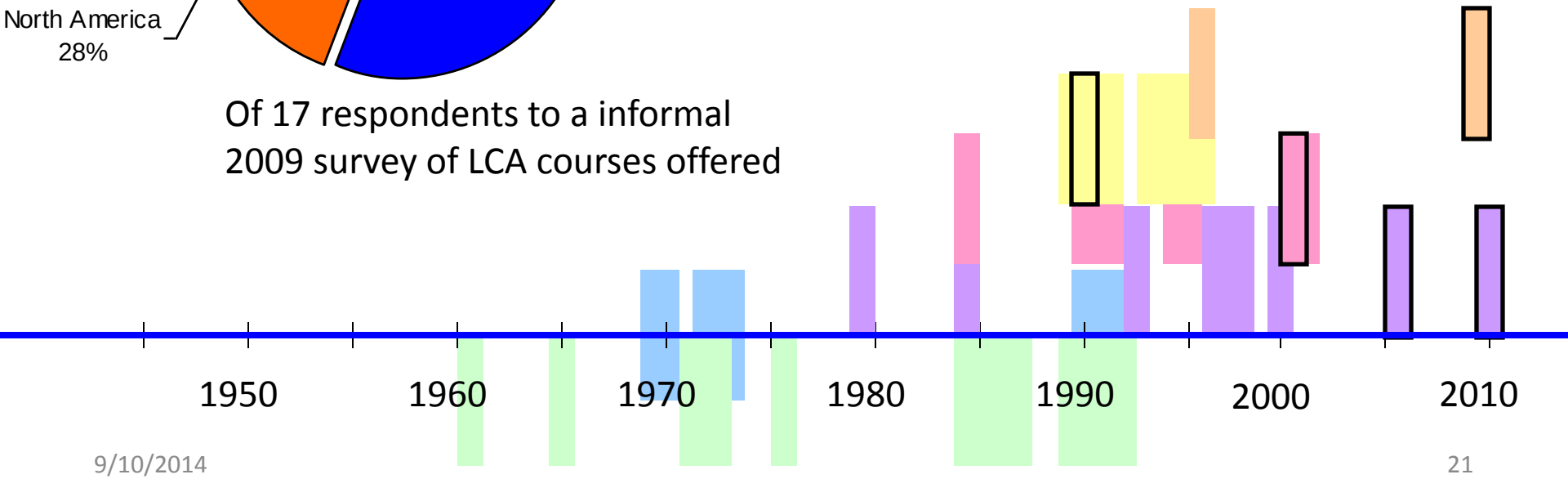

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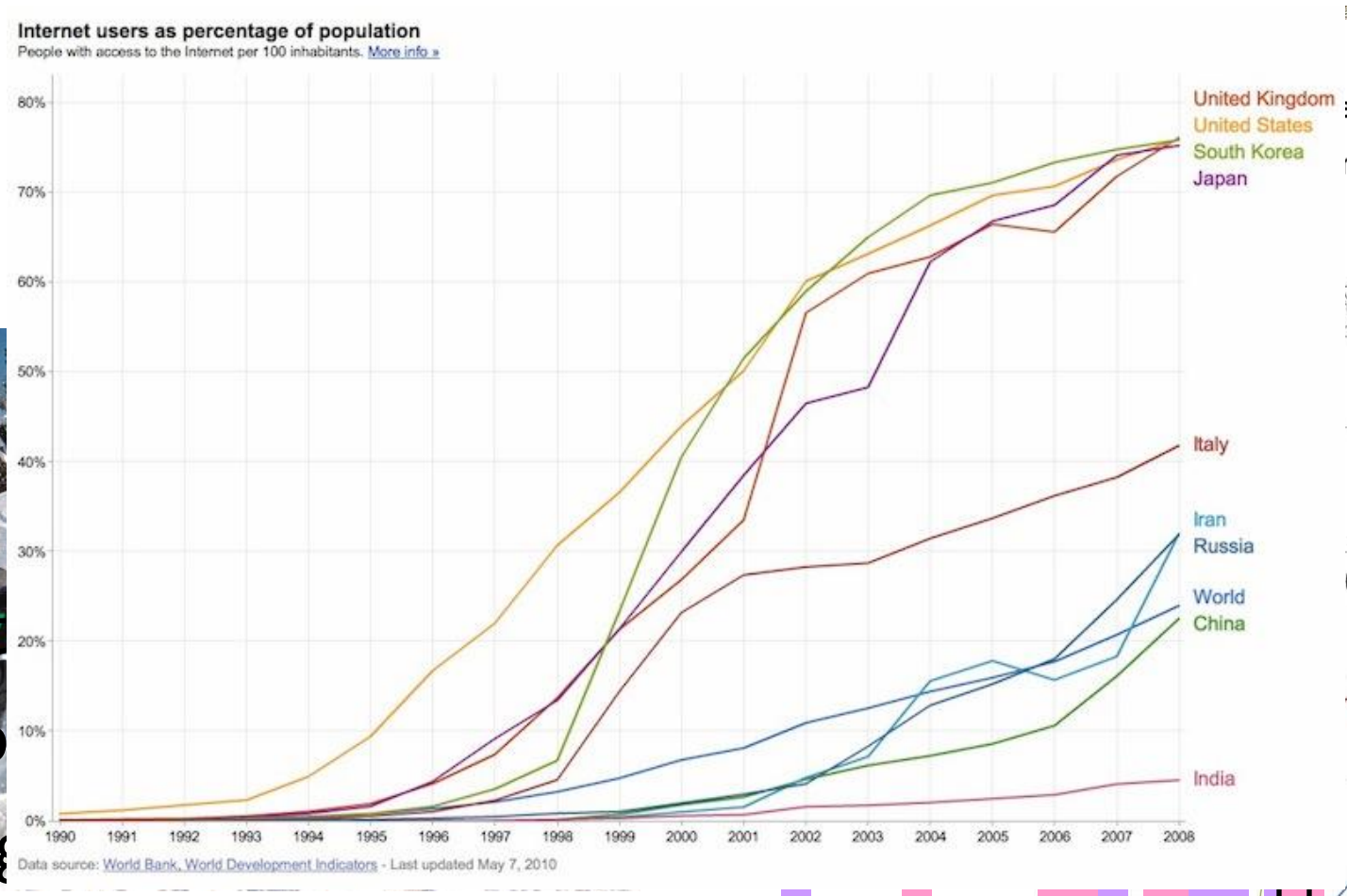
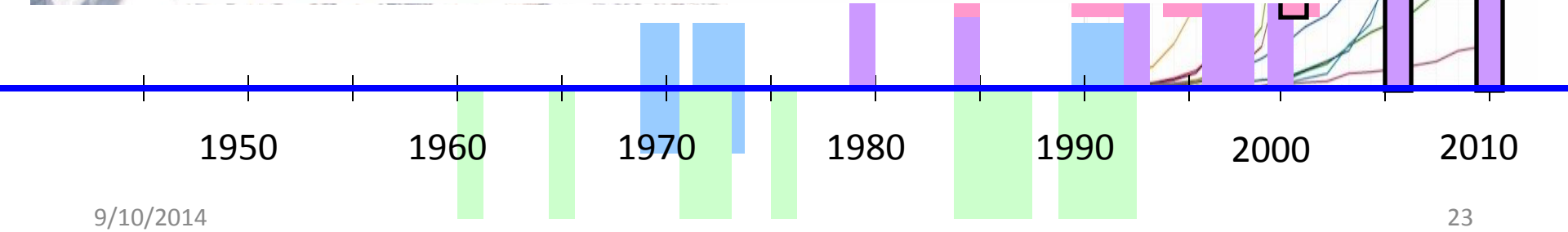


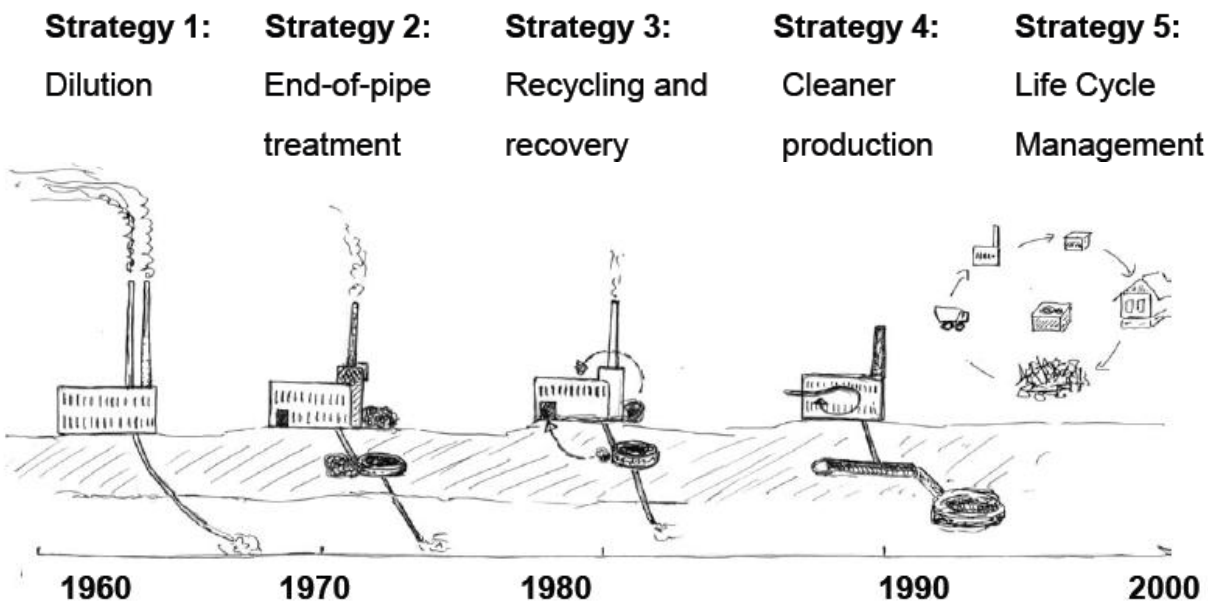
Evolut

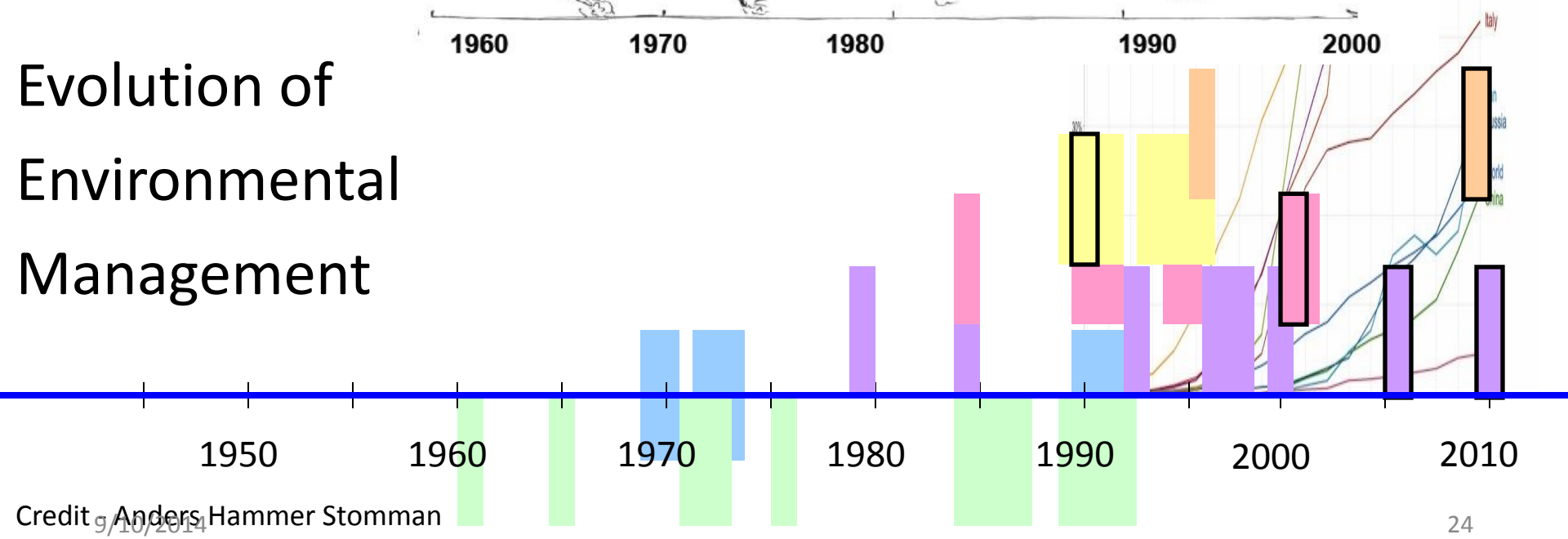
Enviro

Manag



Evolution of Environmental Management





Credit – Anders Hammer Stomman
Norwegian University of Science and Technology

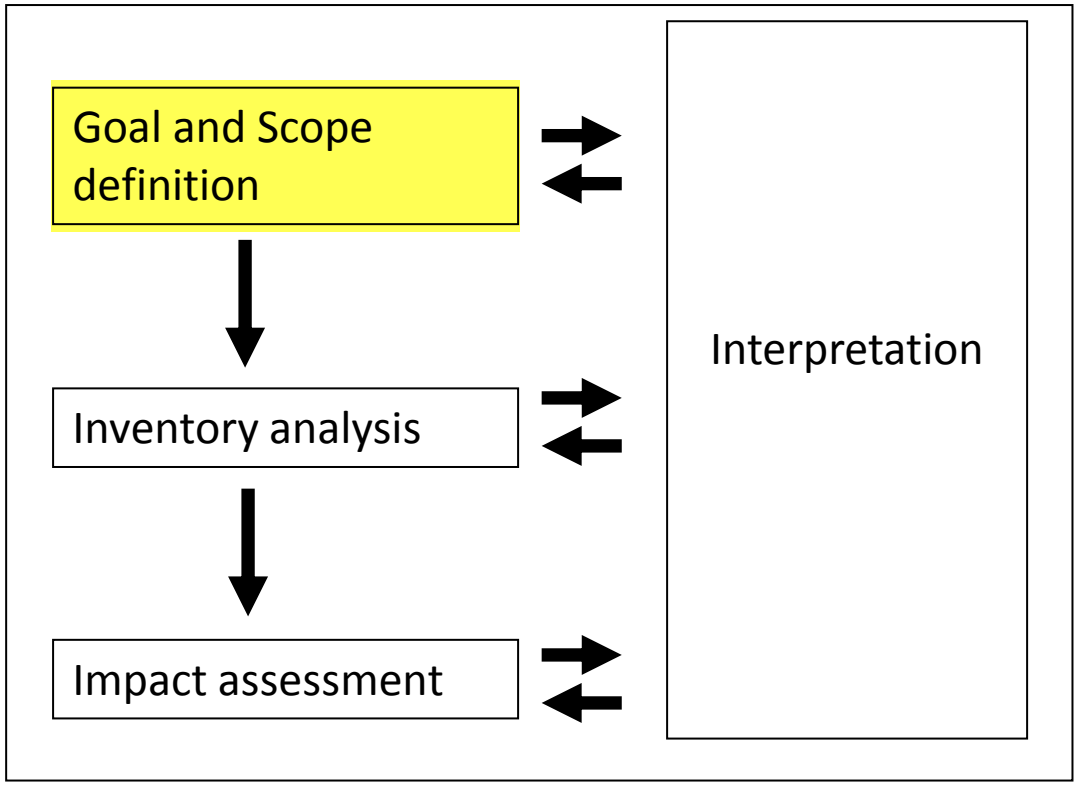
Presentation Outline

1. About me
2. History
3. **LCA method**
4. Sustainability Framework

Life Cycle Assessment

Framework

Defining and planning the study to be carried out on the system in question.



(ISO 14040:2006)

Goal & Scope

State the;

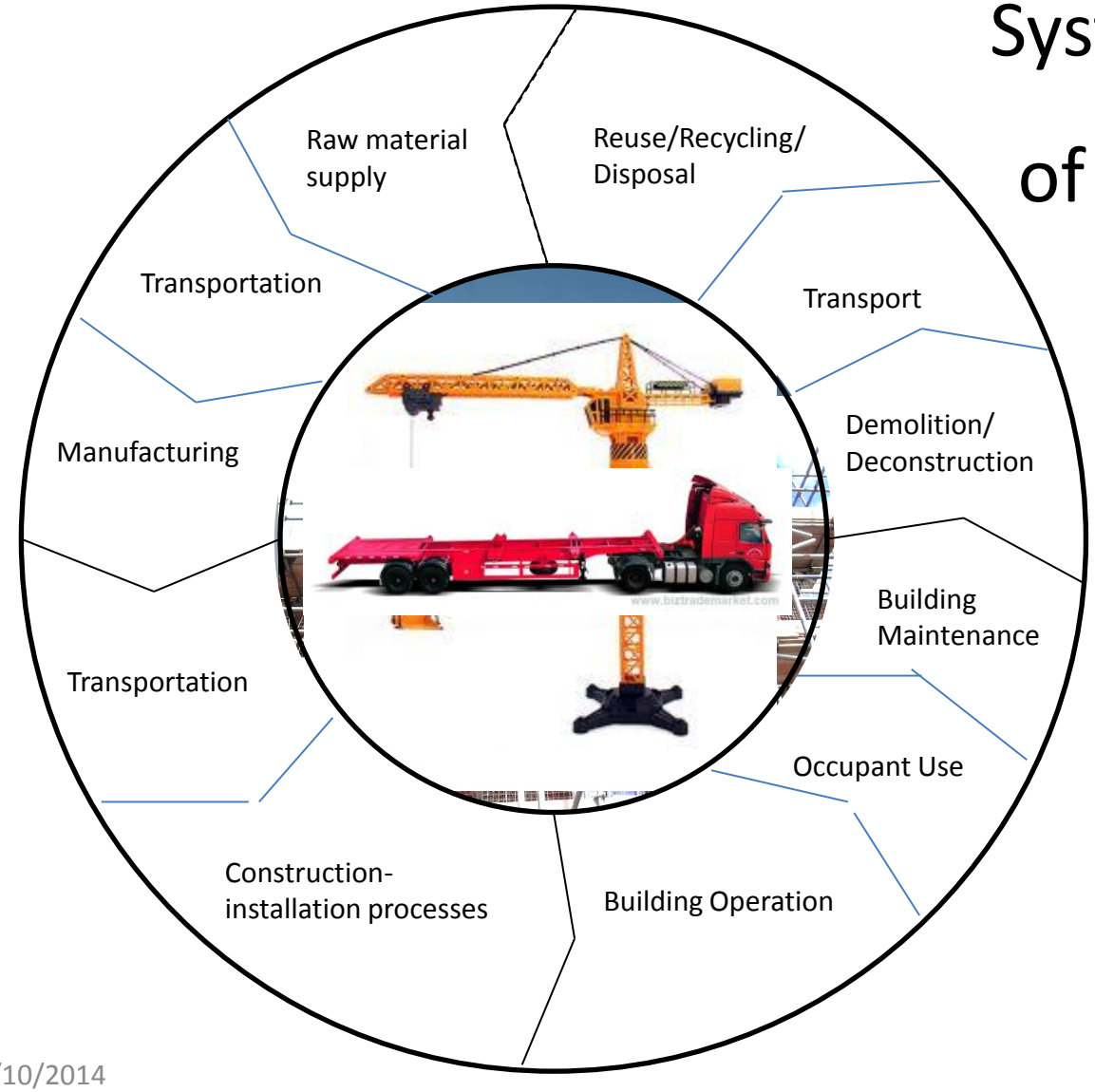
- ❑ Intended application
- ❑ Reasons for carrying out the study
- ❑ Intended audience
- ❑ Intended for comparative assertions

All information related to modeling that is to be carried out, specifically the;

- ❑ Product system to be studied
- ❑ Functions of the product system or, in the case of comparative studies, the systems
- ❑ Functional unit
- ❑ System boundary
- ❑ Allocation procedures
- ❑ Impact categories selected and methodology of impact assessment, subsequent interpretation to be used
- ❑ Data sources
- ❑ Assumptions
- ❑ Limitations
- ❑ Initial data quality requirements
- ❑ Type of critical review, if any
- ❑ Type and format of the report required for the study

ISO 14044:2006(E)

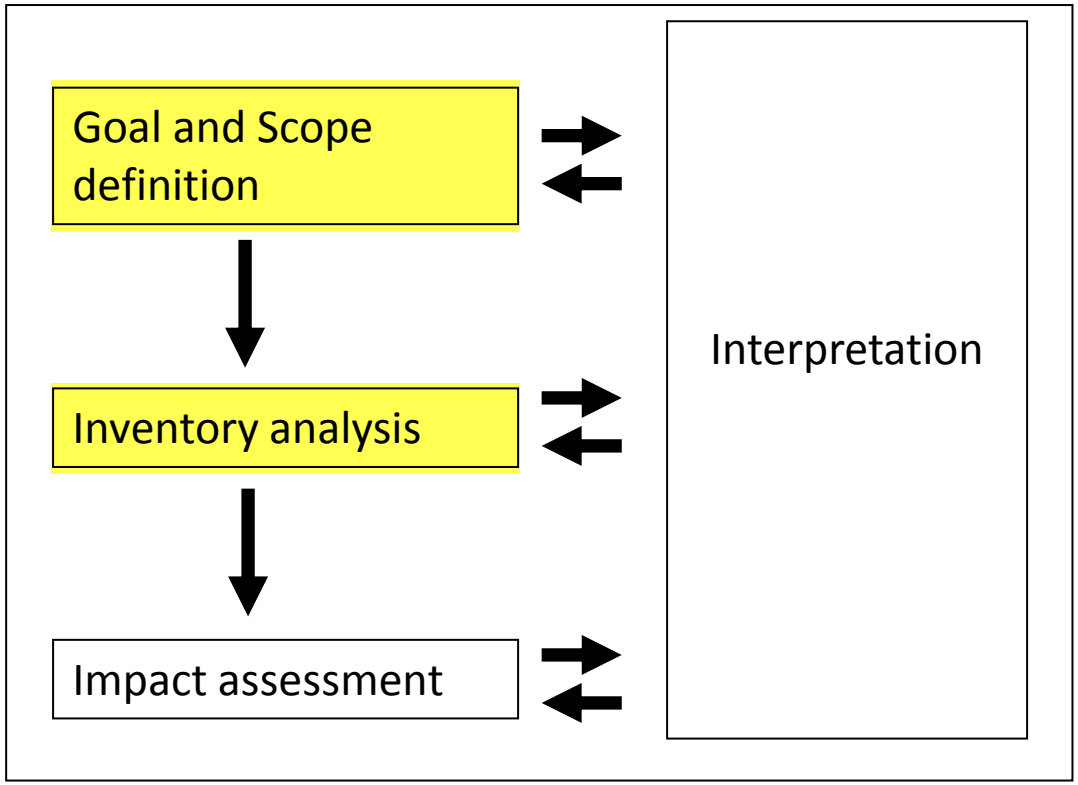
System Boundaries of Product System



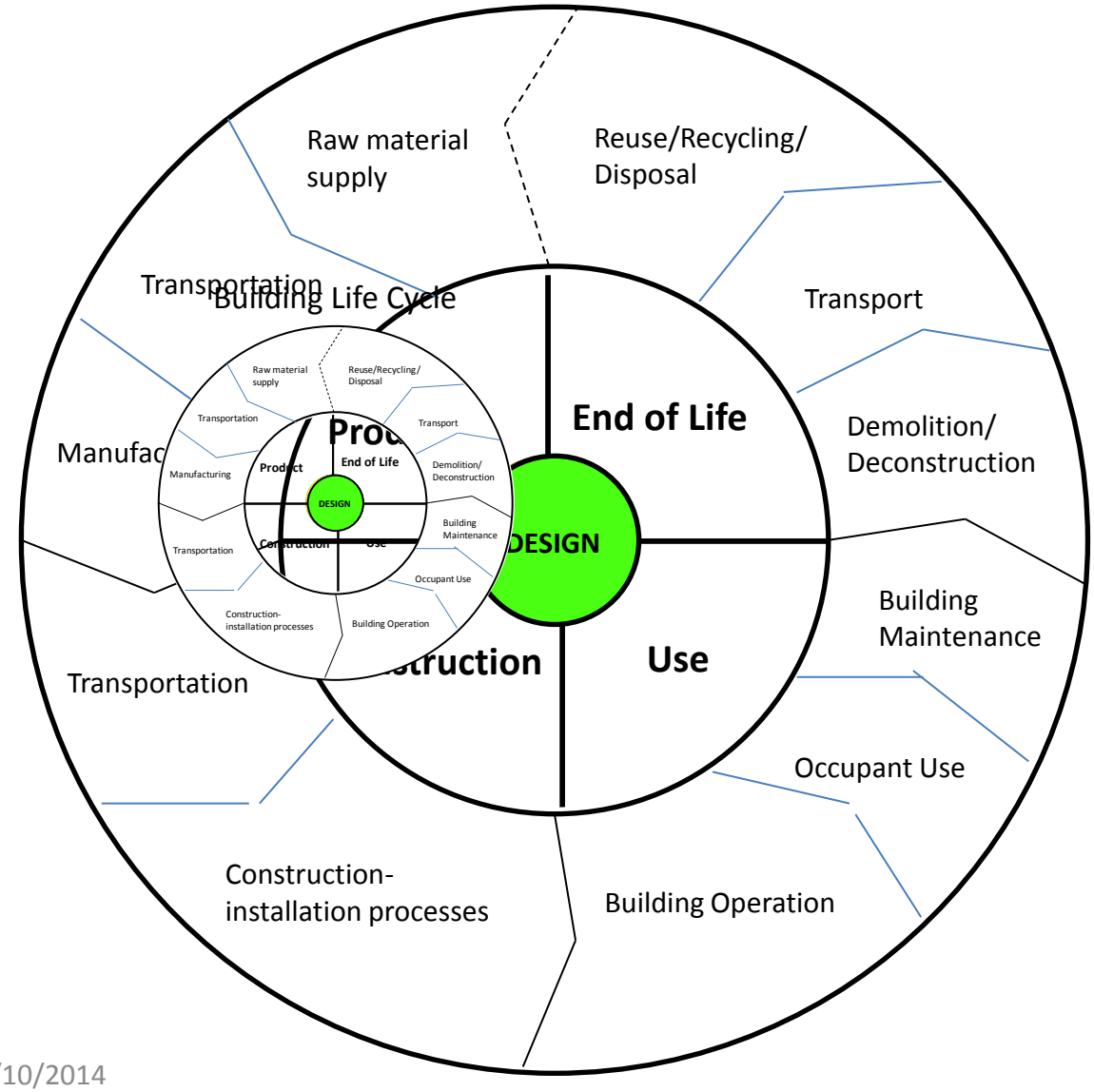
Life Cycle Assessment Framework

Defining and planning the study to be carried out on the system in question.

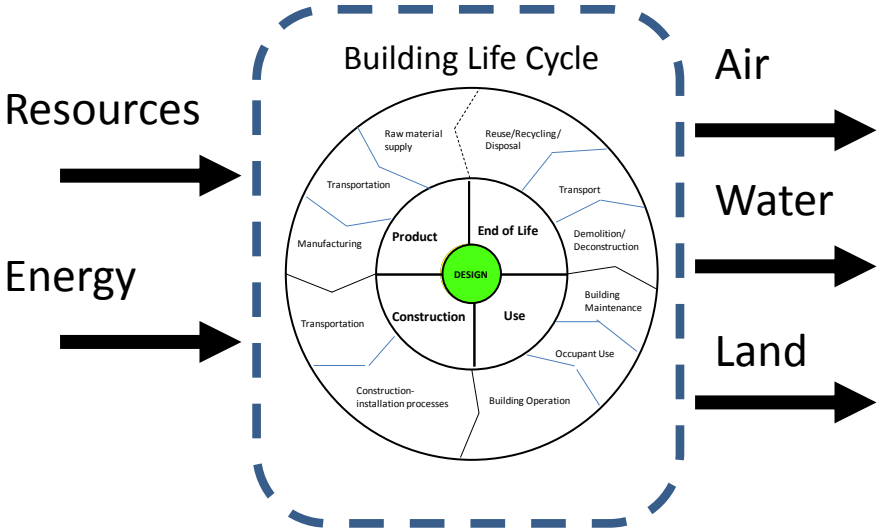
Measuring physical inputs and outputs from the system in question.



(ISO 14040:2006)


Raw material supply
Reuse/Recycling/ Disposal
Transportation
Building Life Cycle
Transport
End of Life
Demolition/ Deconstruction
DESIGN
Building Maintenance
Use
Occupant Use
Transportation
Construction-installation processes
Building Operation

Inventory Analysis



Inventory Analysis

Quantitative Data Collection

Measure amounts of all required ***flows*** crossing your System Boundary as per your G&S.

Qualitative Data Collection

Describing
- ❑ age of data to be used
- ❑ technology of the process
- ❑ origin of raw materials
- ❑ locality of process
- ❑ impacted environments

Support your allocation
- ❑ prices
- ❑ physical relationships

Transportation
- ❑ distance
- ❑ routing
- ❑ type

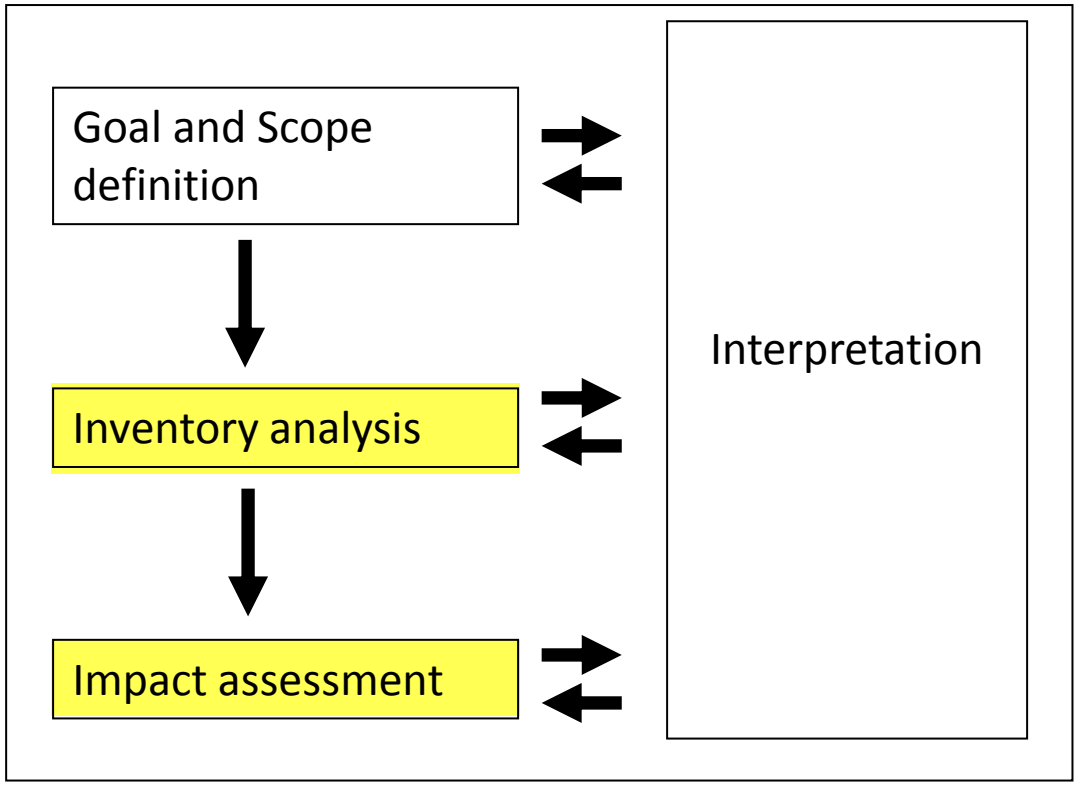
Energy Consumption		SM	DF	
	Hydro	9.7	9.7	MJ
	Diesel	2.1	2.1	MJ
Resource Use				
	Crude Oil	0.8	0.8	L
	SW Fiber		0.2	kg
	HW Fiber	0.2		kg
	Fresh Water	1.0	1.0	L
Emissions to Air				
	CO_2	1.4	1.0	g
	CO	1.0	1.0	g
Emissions to Water				
	Phosphorus	7.6	8.2	g
	Ammonium	5.0	5.0	g
Emissions to Land				
	Chips	0.1	0.1	kg
	Saw Dust	0.1	0.1	kg
Products & Co-products				
	Wood	1.0	1.0	m^3

Life Cycle Assessment Framework

Defining and planning the study to be carried out on the system in question.

Measuring physical inputs and outputs from the system in question.

Assigning an environmental significance to inputs and outputs from the system in question.



(ISO 14040:2006)

Impact Assessment

Energy Consumption		HW	SW	
	Hydro	9.7	9.7	MJ
	Diesel	2.1	2.1	MJ
Resource Use				
	Crude Oil	0.8	0.8	L
	SW Fiber		0.2	kg
	HW Fiber	0.2		kg
	Fresh Water	1.0	1.0	L
Emissions to Air				
	CO_2	1.4	1.0	g
	CO	1.0	1.0	g
Emissions to Water				
	Phosphorus	7.6	8.2	g
	Ammonium	5.0	5.0	g
Emissions to Land				
	Chips	0.1	0.1	kg
	Saw Dust	0.1	0.1	kg
Products & Co-products				
	Wood	1.0	1.0	m^3

Impact Assessment

Global Warming Potential

- An air emissions potential capacity to absorb infrared radiation and heat the atmosphere.

- Expressed in kg CO_2 equivalence

Impact Assessment

Global Warming Potential

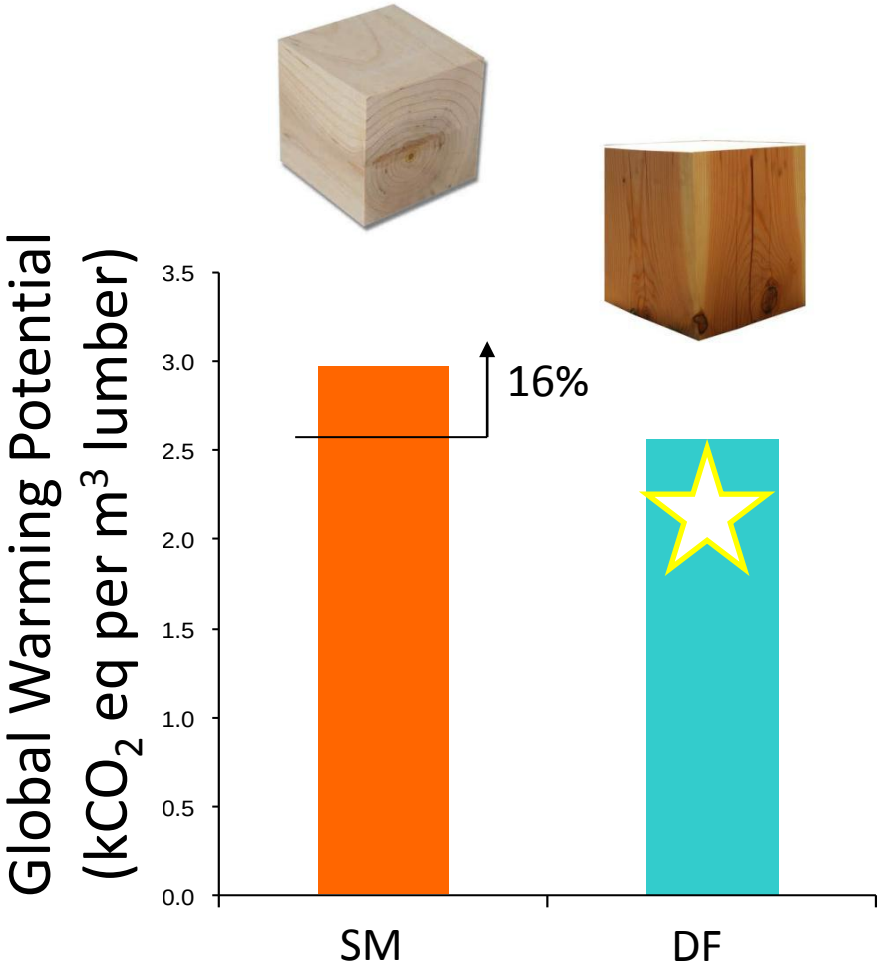
Substance	GWP Characterization Factors
Carbon dioxide (CO_2)	1
Carbon monoxide (CO)	1.57
Methane (CH_4)	23
Sulfur hexafluoride (SF_6)	22,450
HFC-23	14310
HFC-152a	122

IPCC, 2007

Energy Consumption		SM	DF			Characterization factors GWP		Impact Assessment SM	DF
	Hydro	9.7	9.7	MJ					
	Diesel	2.1	2.1	MJ					
Resource Use									
	Crude Oil	0.8	0.8	L					
	SW Fiber		0.2	kg					
	HW Fiber	0.2		kg					
	Fresh Water	1.0	1.0	L					
Emissions to Air								**GWP**	
	CO_2	1.4	1.0	g	X	1.00	=	1.40	1.00
	CO	1.0	1.0	g	X	1.57	=	1.57	1.57
								2.97	**2.57**
Emissions to Water									
	Phosphorus	7.6	8.2	g					
	Ammonium	5.0	5.0	g					
Emissions to Land									
	Chips	0.1	0.1	kg					
	Saw Dust	0.1	0.1	kg					
Products & Co-products									
	Wood	1.0	1.0	m^3					

LCIA Results

(Life Cycle Impact Assessment)



Impact Assessment	
SM	**DF**
GWP	
1.40	1.00
1.57	1.57
2.97	**2.57**

Life Cycle Assessment Framework

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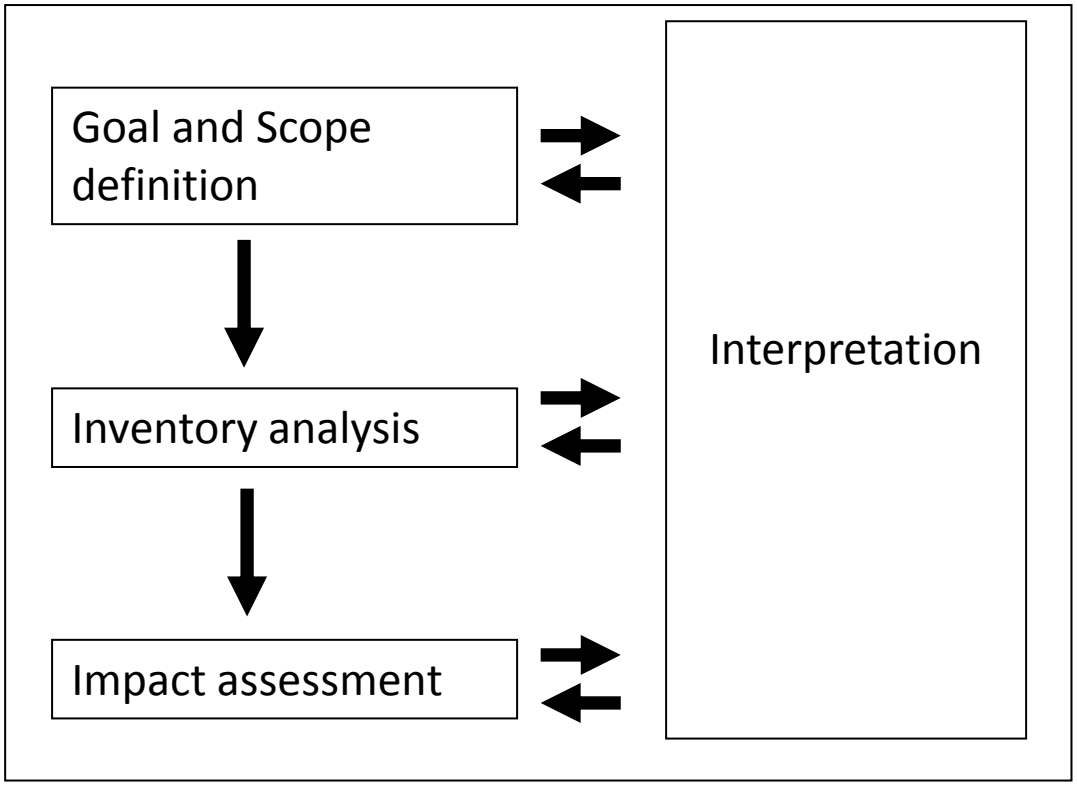

(ISO 14040:2006)

Presentation Outline

1. About me
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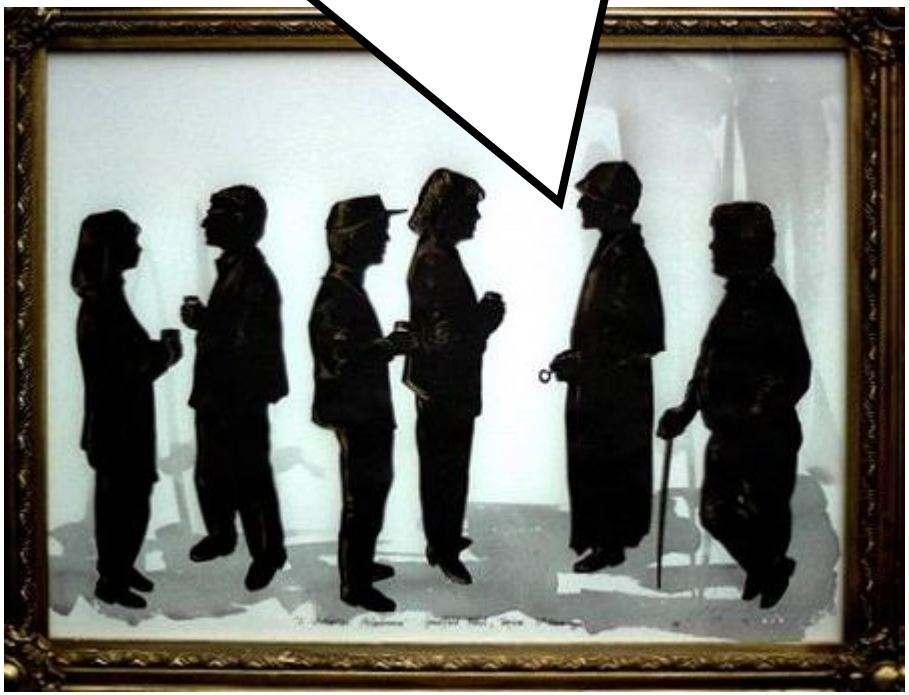
4. **Sustainability Framework**

What is a life cycle assessment?

Life cycle approach

"It's a scientific method used to quantify the impacts created by products over their life cycle."

Usually environmental

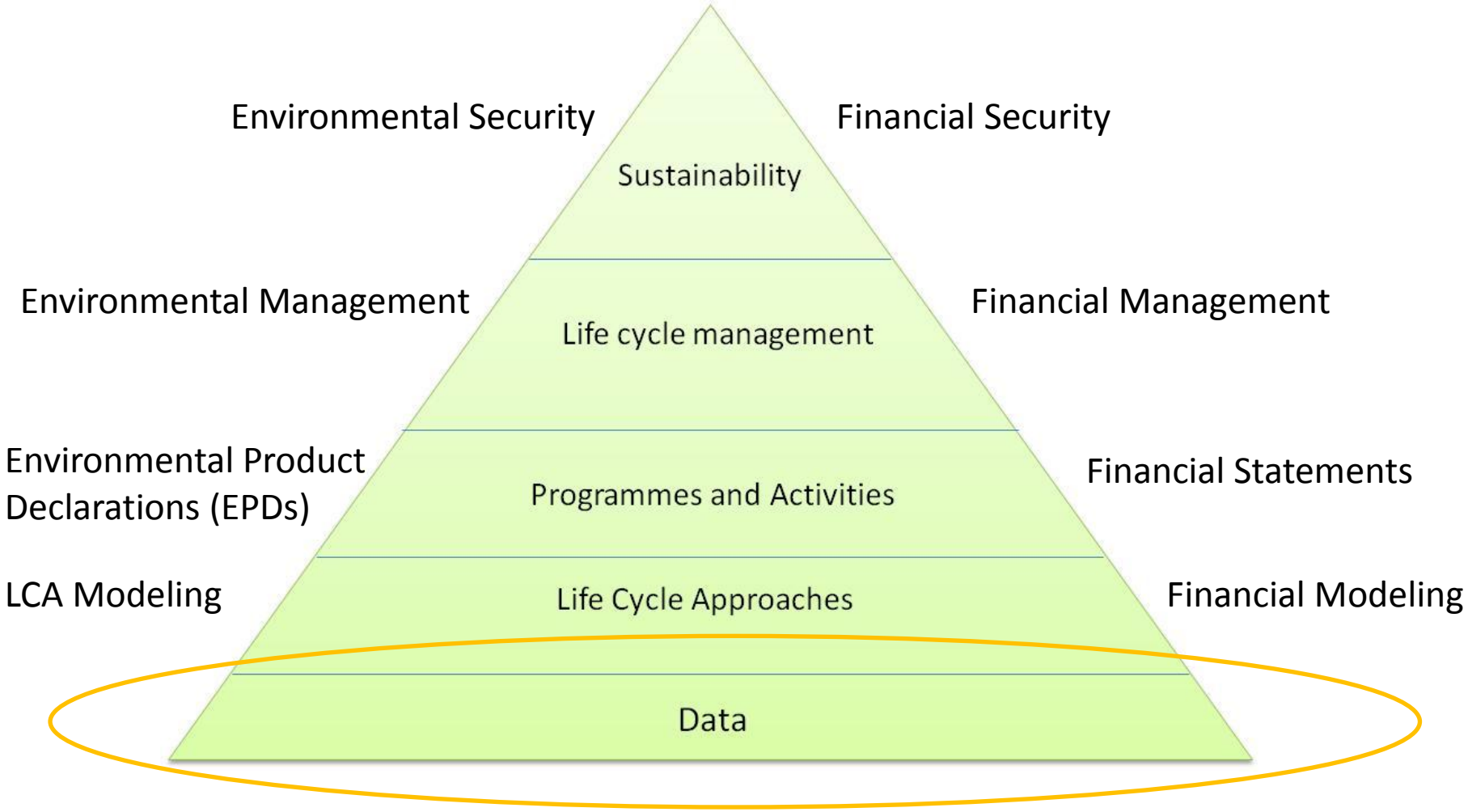


ie. goods and services.

Both are Life Cycle Approaches

life cycle assessment $\neq$ life cycle costing

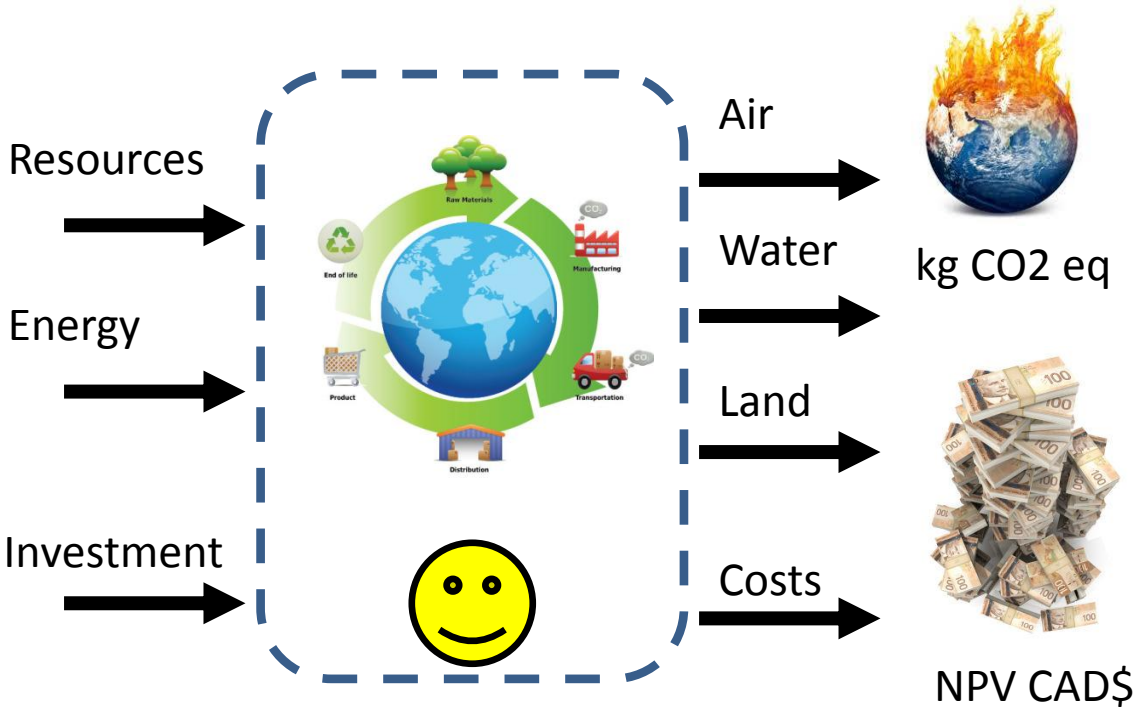
UNEP/SETAC Sustainability Framework



Data

Inventory Analysis

Impact Assessment



Data

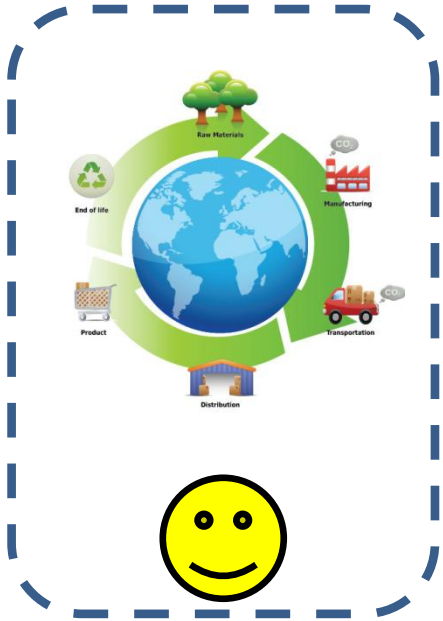
Inventory Analysis

Impact Assessment

Resources

Energy

Investment



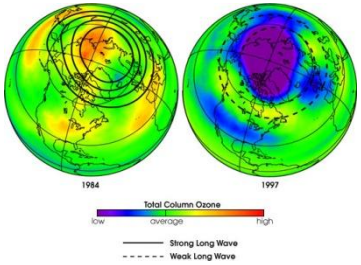
Air

Water

Land

Costs

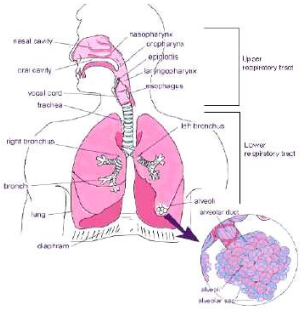
kg CO2 eq



kg CFC-11 eq

kg SO2 eq

NPV CAD$

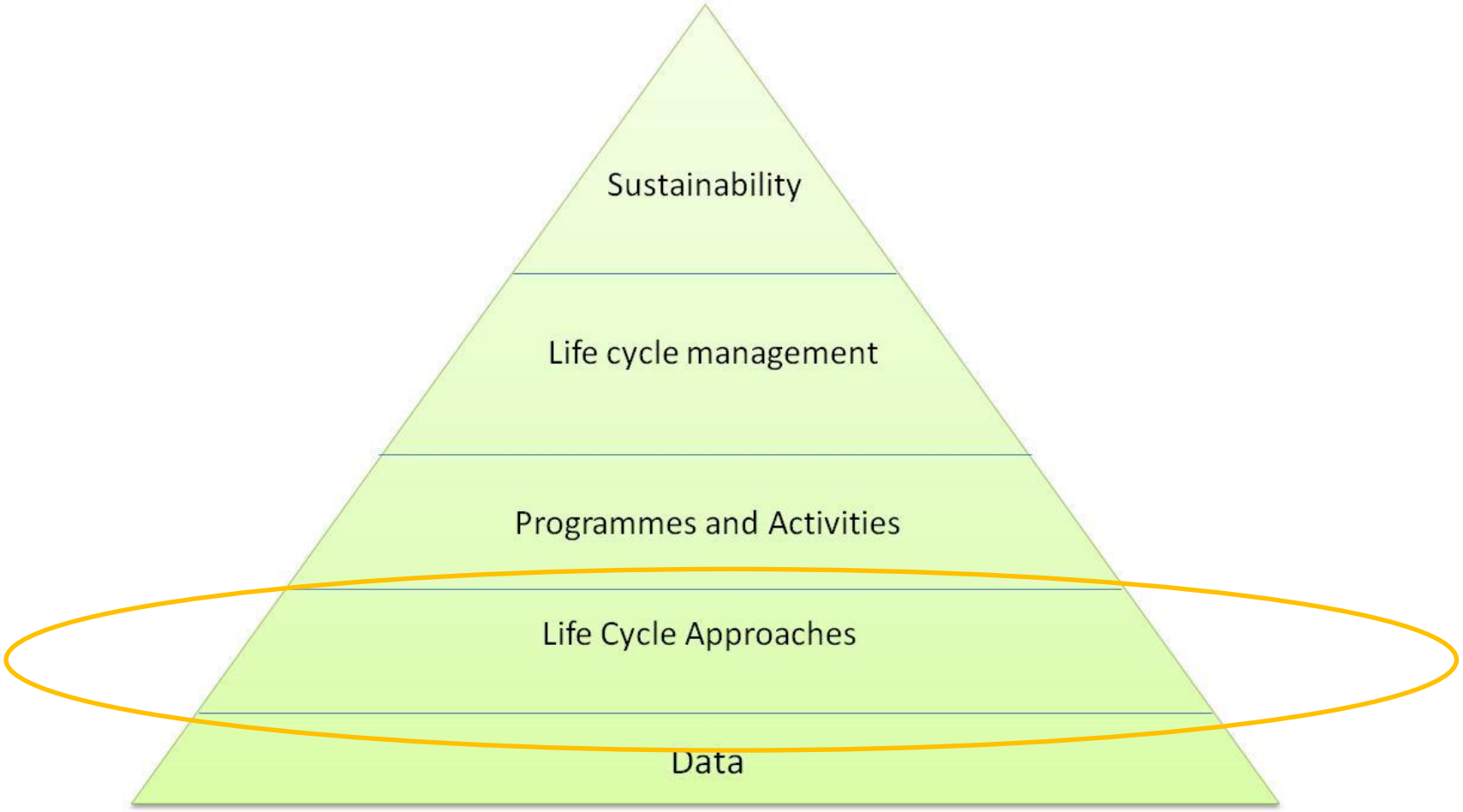


kg PM10 eq

kg N eq

kg O3 eq

UNEP/SETAC Sustainability Framework



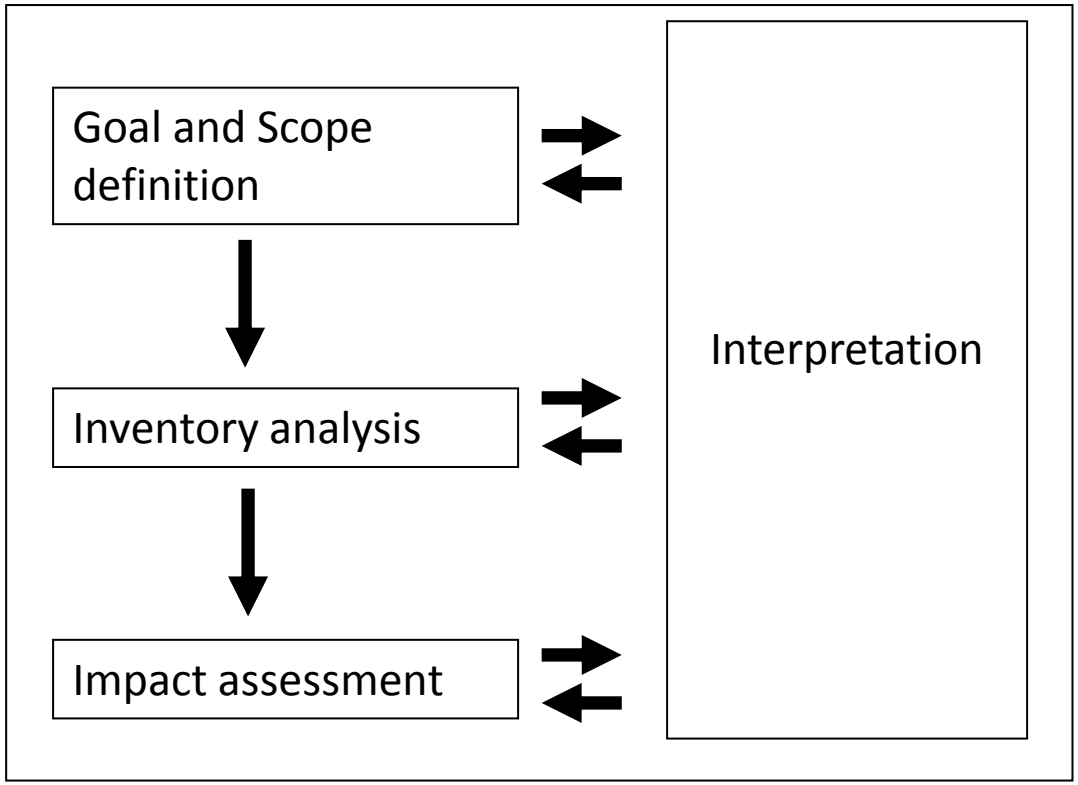
Guiding Standards for LCA

- **ISO 14040**:2006, Environmental management – Life cycle assessment – **Principles and framework**

- **ISO14044**:2006; Environmental management – Life cycle assessment- **Requirements and guidelines**

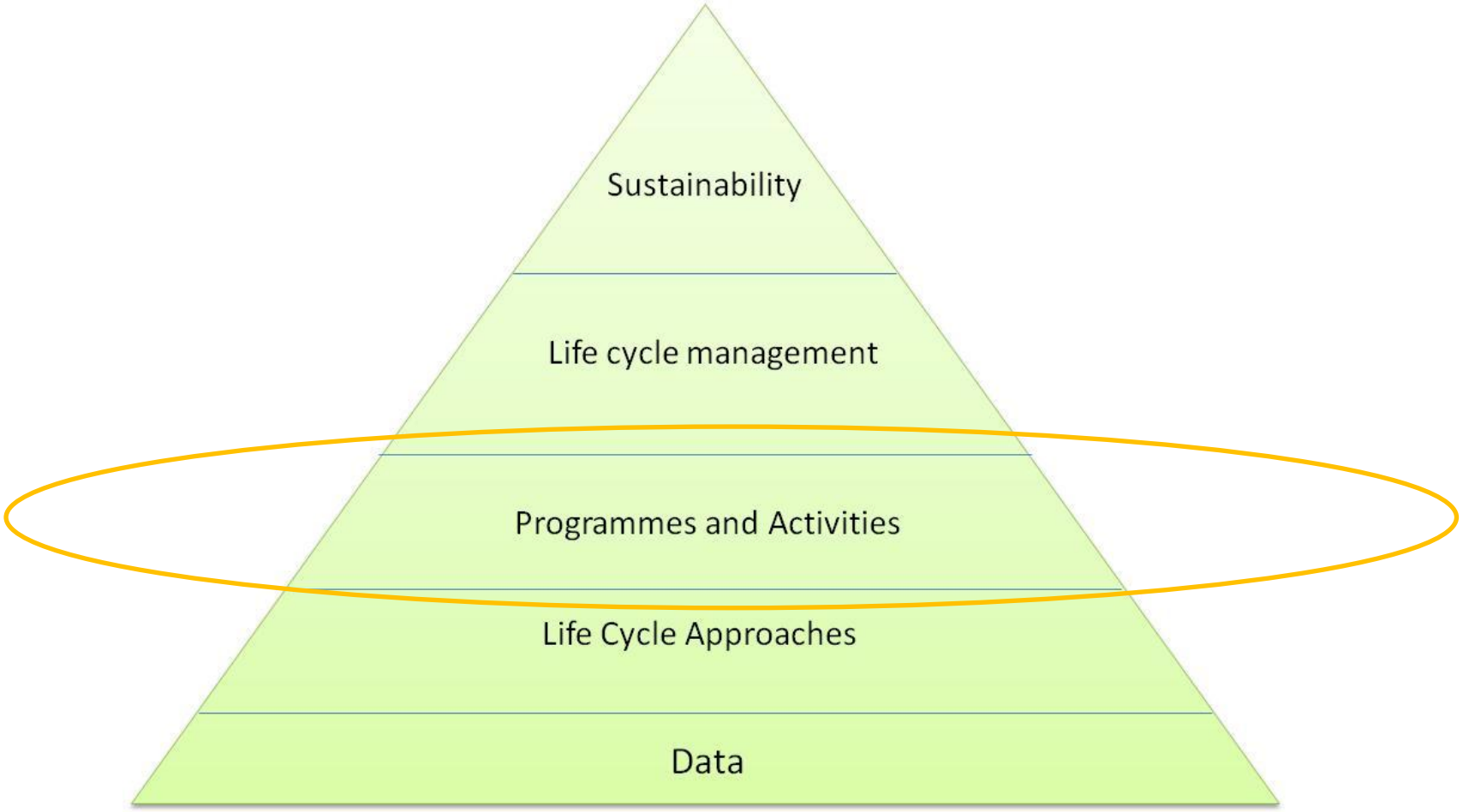
Life Cycle Approaches

Life Cycle Assessment Framework



(ISO 14040:2006)

UNEP/SETAC Sustainability Framework



Programs and Activities

PCRs
(Product Category Rules)

LCA (Life Cycle Assessment) study

EPD
(Environmental Product Declaration)

Programs and Activities

Environmental Product Declaration (EPD) Programs for Construction Products.

Programs and Activities

Standards and Guidance Programs for Buildings.

- LEED v.4
- Green Globes
- IgCC
- CalGreen

Guidance

- ISO 21931-1
- EN 15978
- Athena Guidelines

Programs and Activities

Standards and Guidance Programs for Buildings.

– Typical compliance requirement : Design a proposed building that is X% better than a reference building.

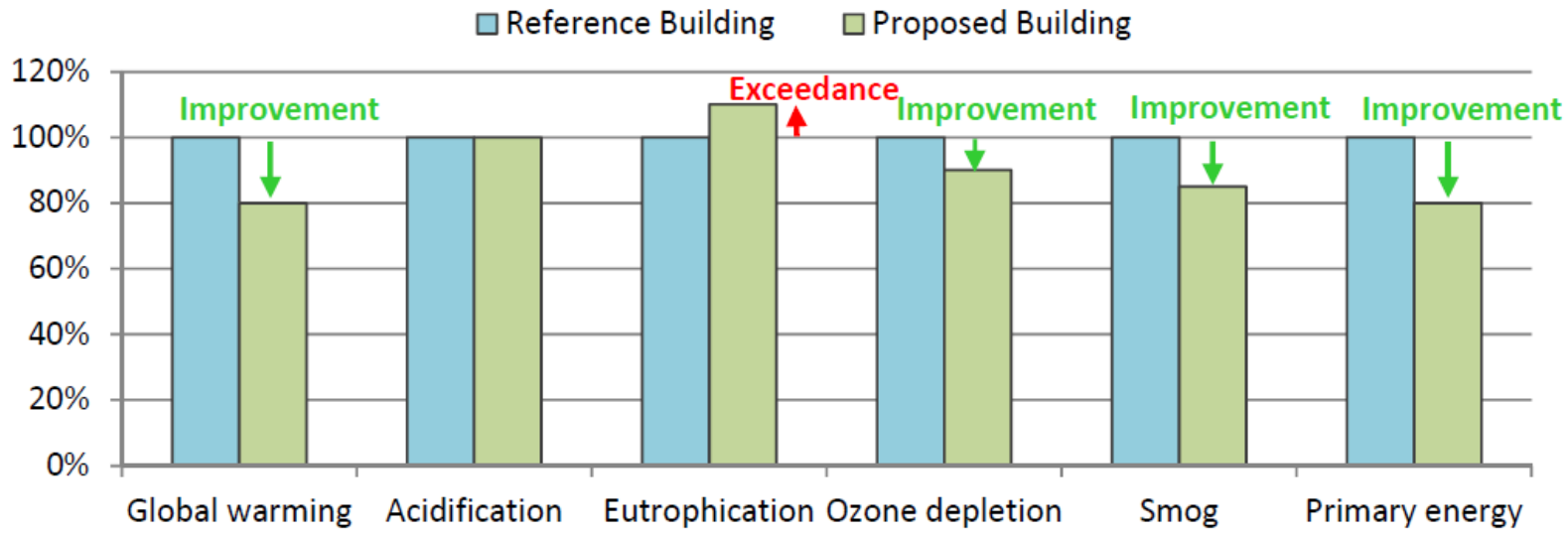


Figure 2: The Comparative Concept in the Green Building Programs

Programs and Activities

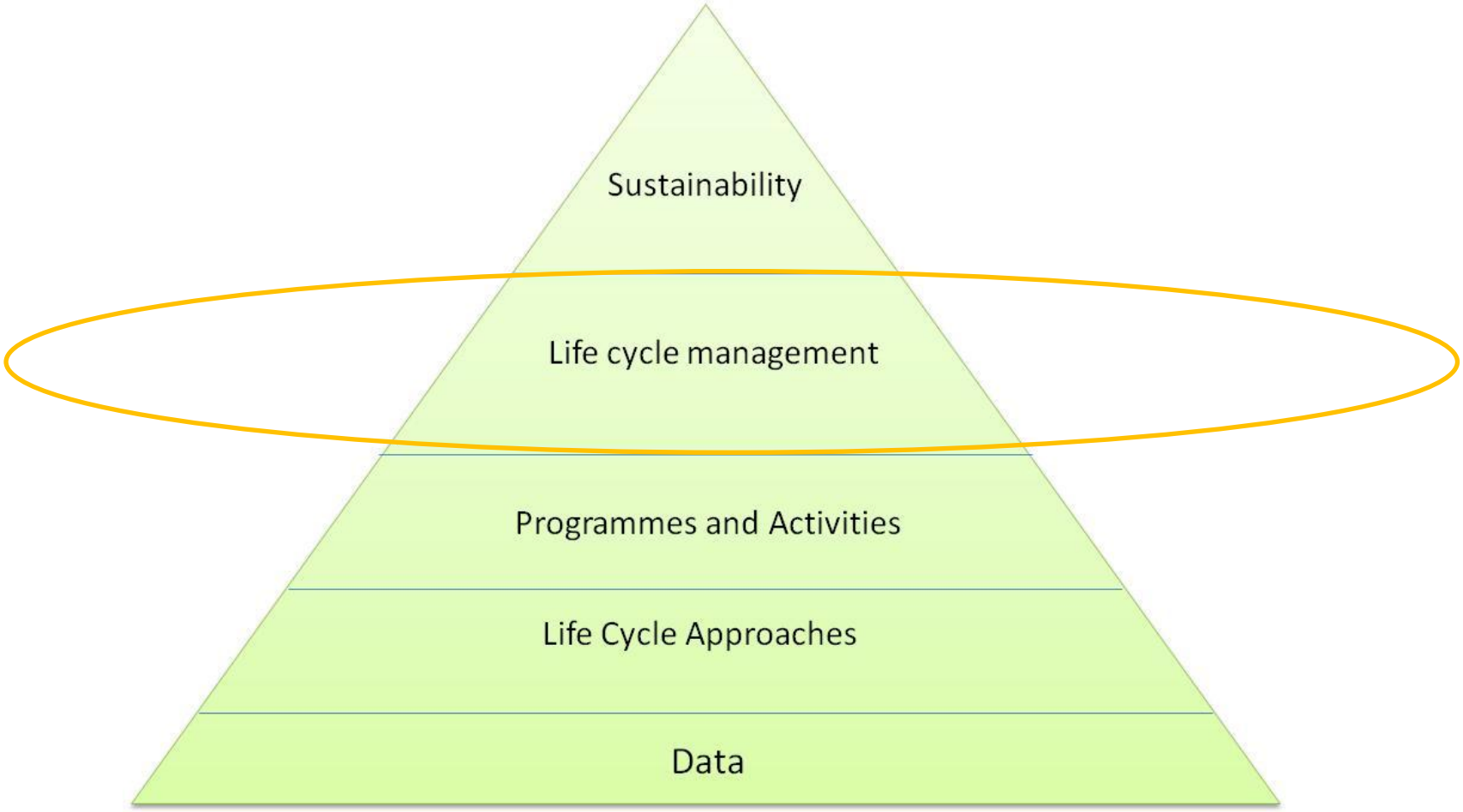
Organizational Activities for Buildings

- Natural Resources Canada
  - Federal Sustainable Development Strategy
  NRCan strategy includes assessment of embodied carbon

- Olympic Games
  - Impact Studies
  En 27: Life-cycle Inventory of Olympic and Paralympic Venues

- University of British Columbia
  - inclusion of LCA in request for information from architects and consulting teams

UNEP/SETAC Sustainability Framework



Life Cycle Management

Consideration in decision making

*Designing and Choosing between options

Life Cycle Management

Consideration in decision making
*Designing and Choosing between options

Table 1: DEC Objects of Assessment Summary

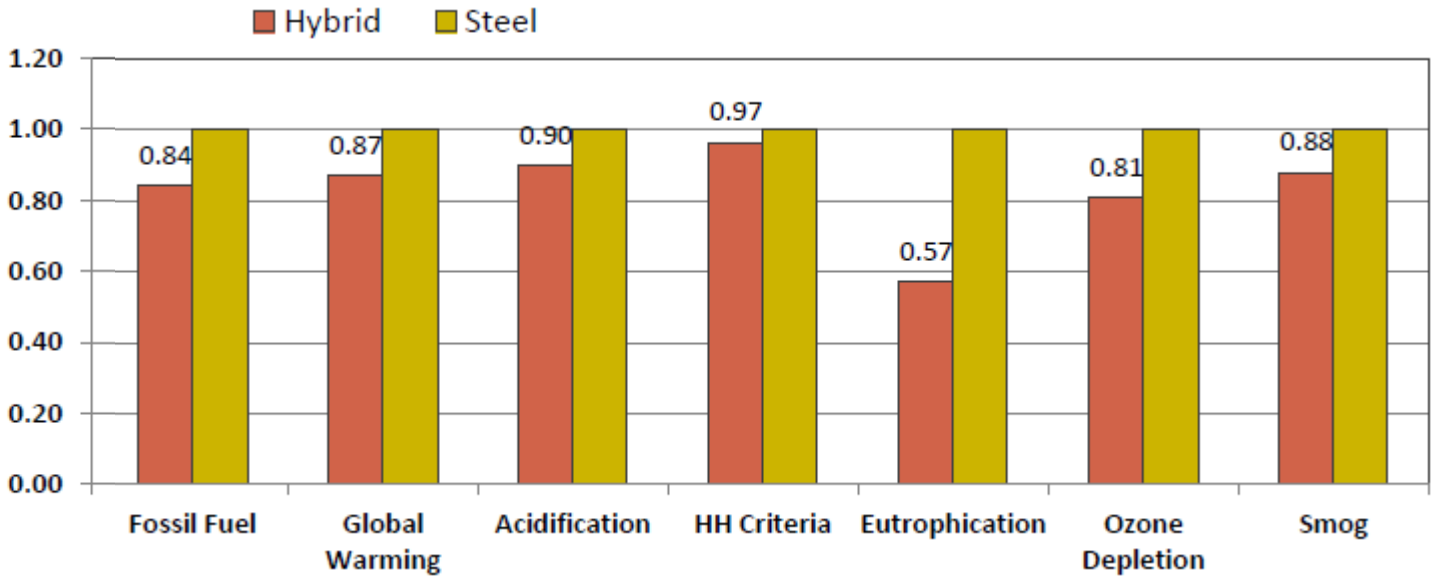
Building Element	OPTION 1: Hybrid Design	OPTION 2: Steel Design
A11 Foundations	Perimeter and interior walls supported by cast-in-place foundation wall and strip footings; perimeter and interior columns supported by piers and pad footings	
A21 Lowest Floor Construction	150mm and 100mm cast-in-place slab on grade on aggregate sub base	
A22 Upper Floor Construction	**Second Floor:** 239mm CLT floor with 50mm concrete topping and 210mm Comfloor composite floor slab supported glulam beams and steel columns	**Second Floor:** 210mm Comfloor composite floor slab supported by steel beams and columns
	Mezzanine: Metal grate supported by steel beams and columns	
A23 Roof Construction	**External walls:** 200mm cast-in-place concrete and 239mm CLT walls	**External walls:** Steel studs infill with exterior sheathing and interior GWB, and 200mm CMU walls
	Lower roof: 239mm CLT and 210mm Comfloor composite deck supported by glulam and steel beams, and steel columns	**Lower roof:** 210mm Comfloor composite deck supported by steel beams and columns
	Upper roof: 239mm CLT deck supported by glulam and steel beams and columns	**Lower roof:** 210mm Comfloor deck supported by steel beams and columns
A32 Walls Above Grade	Aluminum framed glazed curtain wall, and aluminum composite panel and perforated metal panel projections c/w steel supports	
B11 Partitions	**Non-structural:** Gypsum board on both sides of metal studs c/w sounds attenuation batts, and metal framed glazed screens	
	Structural: 99mm and 239mm CLT, and 200mm cast-in-place concrete walls	**Structural:** 200mm CMU walls

Table 1 shows that differences between the two design options analyzed are found within the Upper Floor and Roof Construction, and Partitions elements (A22, A23, and B11), with the remaining elements the same across cases.

Life Cycle Management

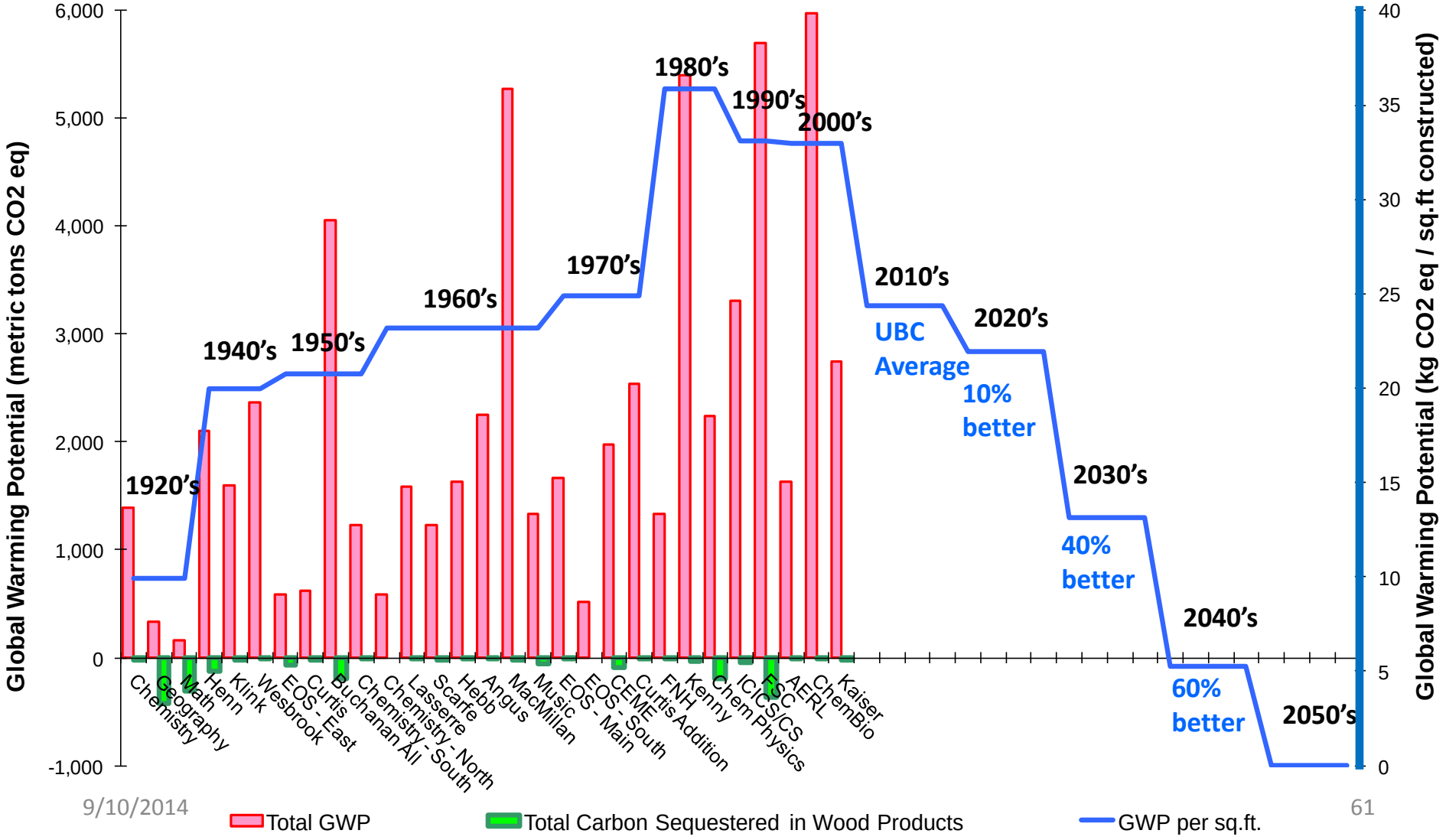
Consideration in decision making
*Designing and Choosing between options

Normalized Environmental Impact Comparison of Proposed and Reference Building Designs

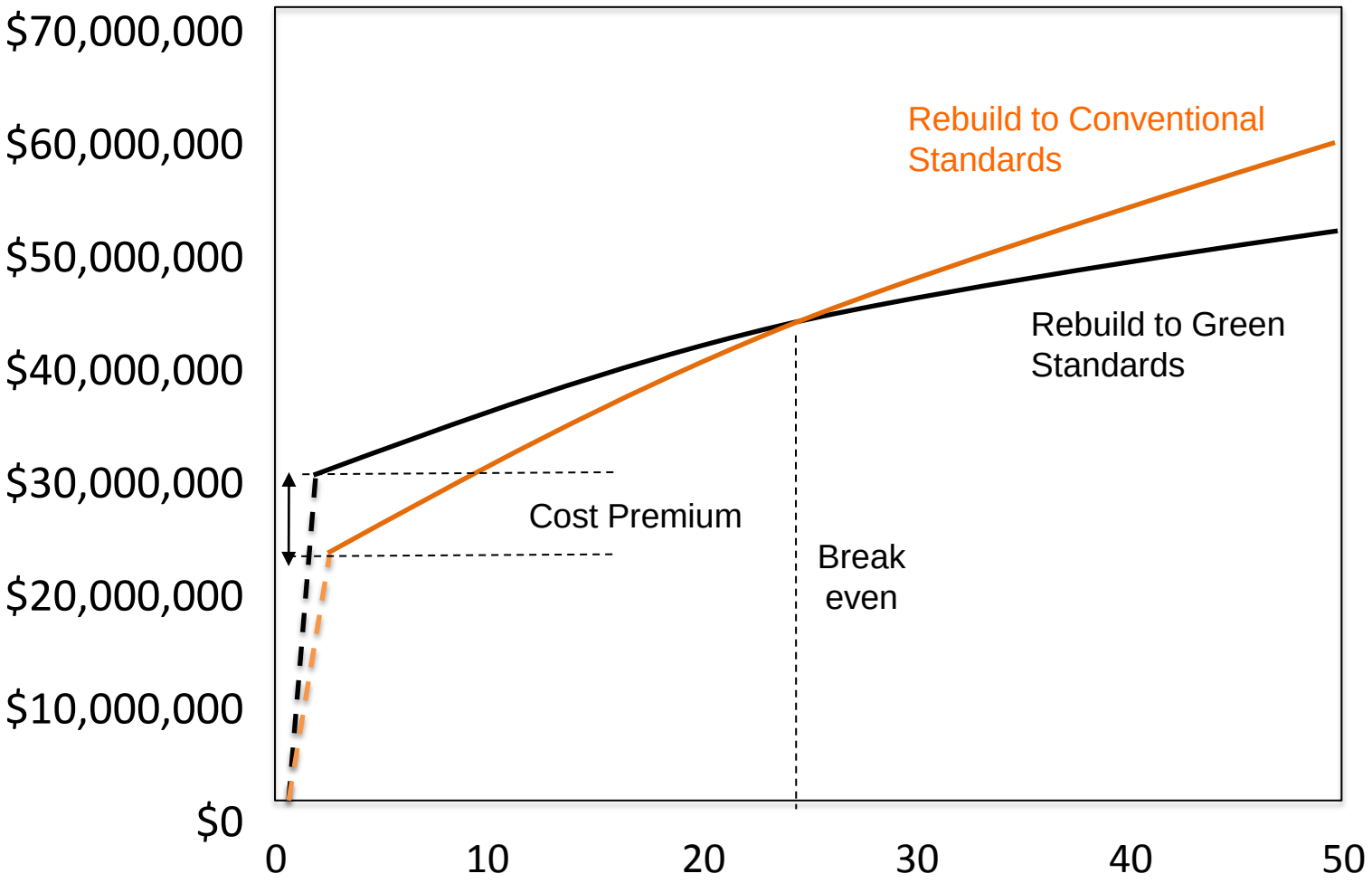


Life Cycle Management

Set performance benchmarks

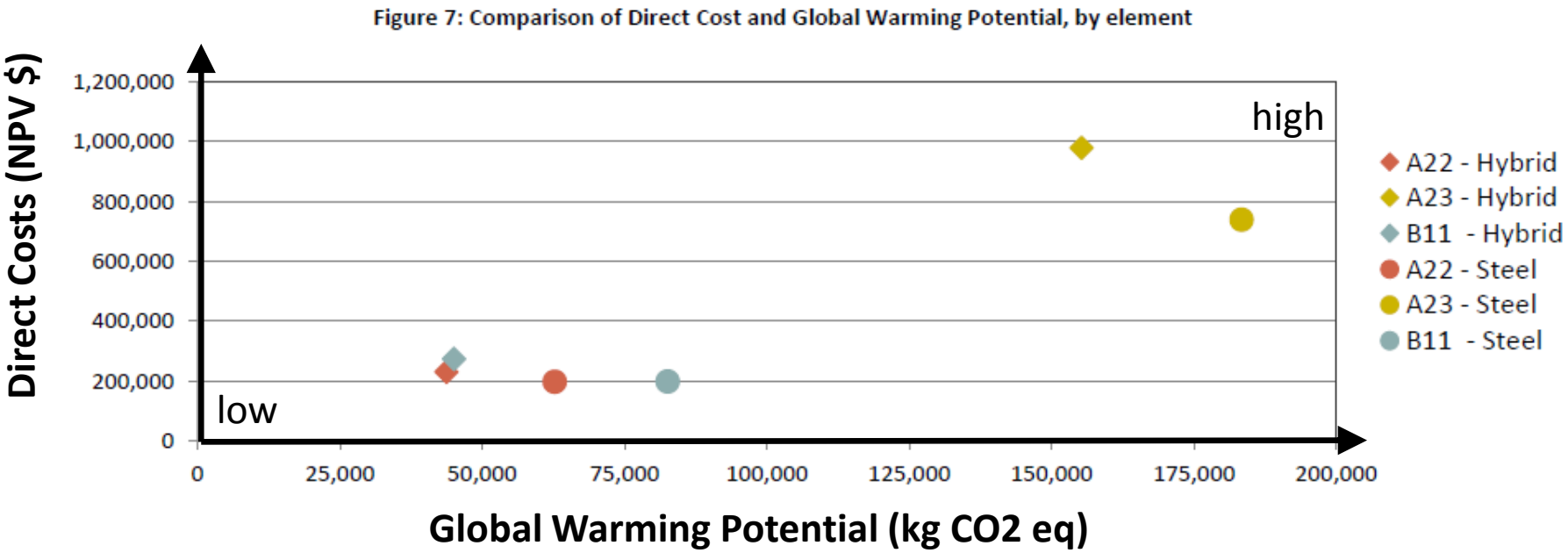


Life cycle costing (LCC)



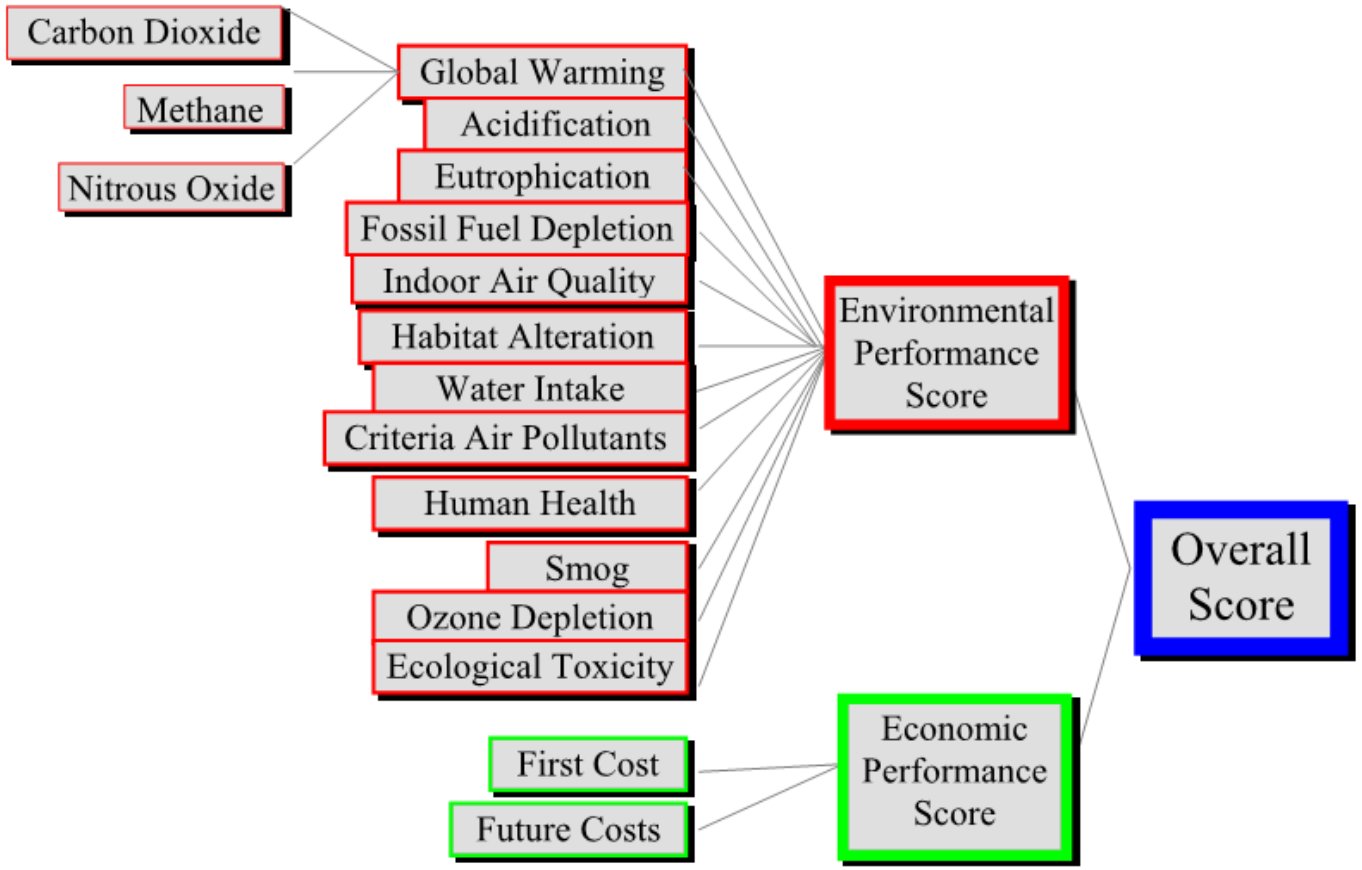
Integrated LCA-LCC Analysis

District Energy Center – Stage 1

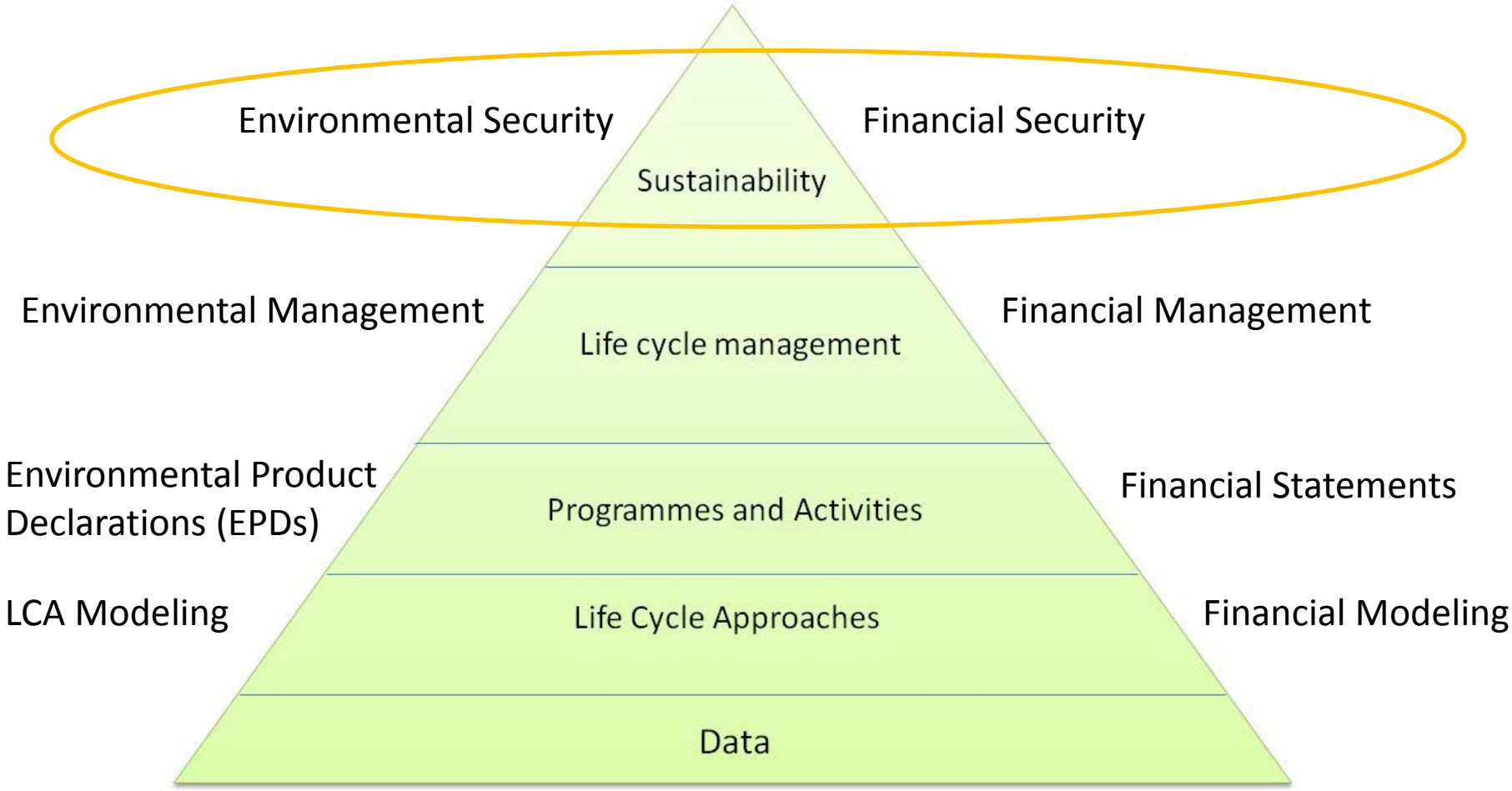


Life Cycle Management

Integrated LCA-LCC Analysis (with weighting)



UNEP/SETAC Sustainability Framework



Sustainability

Inventory Analysis

Impact Assessment

Resources

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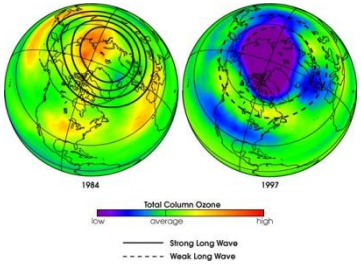
Land

Costs

kg CO2 eq



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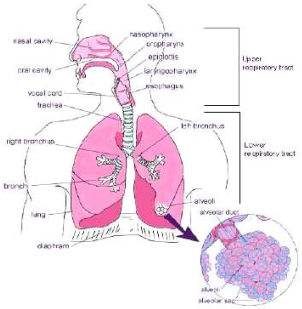

kg PM10 eq

kg N eq

kg O3 eq

Presentation Outline

Coldstream Consulting

1. About me
2. History
3. LCA method
4. Sustainability Framework